DIVISION OF AGRICULTURAL SCIENCES
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LEAST-COST ORGANIZATION OF COTTON GINNING FACILITIES IN THE SAN JOAQUIN VALLEY, CALIFORNIA

By

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The basic objective of this study is to improve the efficiency of cotton assembly, ginning, and storage operations in the San Joaquin Valley, California. The study is designed to determine the number, size, and location of cotton ginning and warehousing facilities that will minimize costs of these operations based on estimated 1975 cotton production levels. Costs are developed using the cost–synthesis approach, and the problem solution is derived using a variation of the linear programming transportation model. The analysis includes consideration of seed cotton storage and extended ginning seasons.

Results of the study indicate that San Joaquin Valley cotton farmers could reduce the costs of assembly, ginning, and storage by 47 percent through implementation of the least–cost system. This system involves cotton gin operation 11 months per year, utilizing stored seed cotton. Processing sites would be located at Bakersfield, Corcoran, and San Joaquin.

ACKNOWLEDGMENTS

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LEAST–COST ORGANIZATION OF COTTON GINNING FACILITIES IN THE SAN JOAQUIN VALLEY, CALIFORNIA

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John C. Moore, Jr.[1] and Richard H. Courtney[2]

INTRODUCTION

Cotton producers, both in California and throughout the United States, are currently faced with a series of problems that seriously affect their future. Perhaps the chief problem is competition from synthetic fibers. Between 1960 and 1971, cotton's share of the fiber market decreased from approximately 65 percent to an estimated 33 percent.[3] Increasing costs of production, processing, and marketing present other problems. The most recent cause of concern for cotton farmers is the prospect of a reduced government role in supplementing cotton producers' incomes.

Of the problems mentioned, increasing costs appear to be the problem over which cotton farmers have the most control. Even in this regard, it is generally acknowledged that the opportunity for significant reductions in production costs is limited. Much greater opportunities exist for cost reductions in seed cotton assembly and ginning. The cost of ginning (the major portion of assembly and ginning costs) has risen dramatically between 1961 and 1971. The average charge for ginning and wrapping a 500–pound cotton bale in California rose from $17.84 to $23.80, an increase of 33 percent during the period.[4]

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[2] Assistant Agricultural Economist in the Experiment Station and on the Giannini Foundation, University of California, Berkeley.

[3] U. S. Economic Research Service, *Cotton Situation,* CS–260 (April, 1973), p. 27.

[4] U. S. Economic Research Service and Agricultural Marketing Service, *Charges for Ginning Cotton, Costs of Selected Services Incident to Marketing, and Related Information,* ERS–2 (1972).

Several research projects concerning costs associated with cotton marketing have stressed the potential for significant savings in the cost of preparing seed cotton for shipment to mills.[1] The studies suggest that there are significant economies of scale in cotton ginning. In most instances, however, the available economies of large plant size are not being fully utilized. Savings also were found to be possible through lengthening the ginning season.

If cost savings can be achieved through operation of larger plants and extended operating periods, information is needed to determine the size, number, and location of plants needed in cotton production areas to minimize total costs. This study was undertaken to provide such information in the form of a long–run organization of gin facilities in the San Joaquin Valley such that the cost of assembling and ginning cotton is minimized. The possible benefits of lengthening the ginning season through seed cotton storage are considered along with the advantages of utilizing larger plants.

The operations considered in this study include the movement of cotton from the farm until it is ready for shipment to domestic or foreign mills. The merchandising of cotton lint is not studied, nor does the project include milling of cottonseed or transport of seed from gin to oil mill.

Research Goals

The research in this study has three goals:

1. Describe the present cotton ginning industry in the San Joaquin Valley including an estimate of the total assembly and processing cost presently incurred by the industry.

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[1] Projects relating to the present study include:

U. S. Farmer Cooperative Service, *Central Cotton Ginning, Comparative Costs, Use in Other Countries, and Potential Use in the United States,* by John D. Campbell, FCS Research Report No. 4 (1969), 46p.

U. S. Economic Research Service, *Economic Models for Cotton Ginning,* by Zolon M. Looney and Charles A. Wilmot, Agricultural Report No. 214 (1971), 48p.

Texas Technical University, Department of Industrial Engineering, *An Industrial Engineering Study of the Operations Through Which Cotton Passes Between the Farm and Mill* (Lubbock, 1970).

Charles D. Covey and James F. Hudson, *Cotton Gin Efficiency as Related to Size, Location, and Cotton Production Density in Louisiana,* Louisiana Agricultural Experiment Station Bulletin 577 (Baton Rouge, 1963), 92p.

2. Determine the size, number, and location of cotton gins in the San Joaquin Valley that will minimize the total cost of assembly and processing based on estimated cotton production levels in 1975. This will include determination of the optimum seasonal length for plant operation.

3. Compare the present performance of the industry in the San Joaquin Valley to the performance possible with the long–run, least–cost organization of plants. The performance comparison is on the basis of cost efficiency.

The study draws as much as possible on data collected in earlier studies; where necessary, the data are adjusted for location and time period differences. The remaining data were collected during 1971 and 1972 from growers, gin managers, marketing personnel, and equipment companies in the San Joaquin Valley.

Location and Importance of the Study Area

California is the third largest cotton production state in the United States, accounting for approximately 13 percent of the nation's 1972 total cotton production. The total value of the 1972 California cotton and cottonseed crop was $291,943,000 which gave it the fourth highest ranking among California agricultural commodities.[1]

California cotton is produced mainly in the San Joaquin Valley, with a small portion––6 percent in 1971––produced in the Imperial Valley. Cotton producing areas within the San Joaquin Valley are geographically determined by the availability of irrigation water, climate, soil characteristics, profitability of competing land uses, and government acreage allotments.[2] Six counties make up the cotton producing region in the San Joaquin Valley––Fresno, Kern, Kings, Madera, Merced, and Tulare (Figure 1). Production totals for each county during the 1960–1971 period are listed in Table 1. Within the six–county region, cotton production occurs in an area approximately 60 miles wide and 150 miles long, extending from the city of Merced on the north to Bakersfield on the south (Figure 1). In the future the area may be extended westward as additional irrigation water becomes available through the West Side irrigation project.[3]

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[1] California Crop and Livestock Reporting Service, *California Agriculture 1972: California's Principal Crop and Livestock Commodities* (Sacramento, 1973), 16p.

[2] By state law, only the Acala variety of upland cotton can be grown in this region.

[3] Gerald W. Dean and Gordon A. King, *Projection of California Agriculture to 1980 and 2000: Potential Impact of San Joaquin Valley West Side Development,* University of California, Giannini Foundation Research Report No. 312 (Berkeley, 1970), 144p.

FIGURE 1. Location of Cotton Production Area in the San Joaquin Valley, California, 1971

TABLE 1

Annual Cotton Production by County,[a] San Joaquin Valley, California, 1960-1971

Year	County						Total
	Fresno	Kern	Kings	Madera	Merced	Tulare	
	1,000 bales						
1960	521	503	220	94	67	328	1,733
1961	433	433	199	87	56	302	1,510
1962	495	514	208	92	60	309	1,678
1963	449	474	200	69	45	263	1,500
1964	465	463	213	79	51	272	1,543
1965	457	446	229	77	47	234	1,490
1966	362	326	172	58	39	158	1,115
1967	318	259	143	58	36	147	961
1968	410	438	214	75	49	228	1,414
1969	367	379	165	65	40	187	1,203
1970	310	352	166	54	36	177	1,095
1971	292	355	171	42	47	143	1,050

a/ Cotton production figures are reported by the U. S. Bureau of the Census only in running bales. This is a measure of the actual number of bales pressed; the weight per bale varies.

Source: U. S. Bureau of the Census, Cotton Production in the United States: Crop of 1960 (1961), and subsequent annual issues.

Total production within the Valley has fluctuated widely but has shown a gradual downward trend during the period shown in Table 1. However, the trend has not been continuous. Production reached a high of 1,733,000 bales in 1960; the low came in 1967 when only 961,000 bales were produced. Production in 1971 was 1,050,538 bales, 9 percent above the 1967 low.

Although the area studied is limited to the San Joaquin Valley, the concepts developed should be applicable with minor modifications to other cotton producing regions.

COTTON GINNING IN THE SAN JOAQUIN VALLEY

Typically, producers haul seed cotton to the nearest gin facility as soon as it is harvested.[1] A pickup truck or tractor pulling a trailer is employed to transport the loose seed cotton to the gin. Hauling distance is usually under 10 miles. Because of the bulkiness of the crop at this stage, growers can only haul the equivalent of 4–8 bales of lint cotton per trailer, depending on trailer size. Gin operators are expected to empty the trailers as soon as possible so that the trailers can be returned to the fields and reused.

Ginning facilities in the San Joaquin Valley receive most of the cotton between October 1 and December 15. Actual receiving rates vary with the harvesting rate. The ginner is expected to gin the cotton and issue a receipt with minimal delay. If the gin facility has insufficient capacity to meet the demands of growers, they will be lost to competing gins nearby. Producers demand a fast ginning service for three principal reasons: (1) they wish to reuse their trailers as soon as possible; (2) the lint cotton sample, which is required before producers can receive payment for their crop, is not taken until the crop is ginned; and (3) in the past, government loans through the price–support program have been available only on baled cotton. Because of these factors, the demand for ginning services closely parallels seasonal harvesting patterns. This means that the gin operation reaches its peak between October 20 and November 20, the usual peak harvest season. During this peak period, gin facilities often operate for 22 hours or more per day; but in nonpeak periods, facilities may operate only sporadically. Further, the widespread use of machine harvesters has shortened the harvest season and has placed an even greater strain on ginning capacity during the peak period.

Soon after the cotton is processed and packaged at the gin, producers (or the new owners if it is sold at the gin) want it hauled to the warehouse compress. Here it is usually weighed, sometimes sampled, stored under cover, and a negotiable warehouse receipt

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[1] Seed cotton refers to that portion of the crop which is harvested in the field; at this stage, the fibers are attached to the cottonseed. Lint cotton refers to the fibers after they have been detached from the cottonseeds in the ginning process. Cottonseed is a by–product of the cotton crop and is, among other things, a valuable source of vegetable oil.

issued. The bale is usually recompressed to a higher density before shipment to the mill. Cotton bales are then shipped by rail or truck to the mills along the southeastern seaboard. For the export market, the cotton is trucked to nearby ports such as Stockton.

Problems Associated with Providing Ginning Services

Gin facilities have been built throughout cotton production areas at relatively close intervals for three principal reasons: (1) growers prefer not to haul their loose seed cotton any further than absolutely necessary; (2) growers prefer not to wait any substantial period of time to have their trailers unloaded and their cotton processed; and (3) they often feel that only their own gin or a local cooperatively owned gin will provide the quality of service that will bring them the highest prices.

Like most agricultural processing operations, cotton gin plants operate only during the harvest season.[1] Even during much of the harvesting season, the gin receives enough volume to operate for only limited periods each day, while ginning crews are usually hired for an entire day. Since the gin facility remains idle during the remainder of the year, gin operators are faced with excess capacity during all but four to six weeks each year.

The principal problem confronting ginning companies has been the need for increased annual volume per gin battery.[2] Higher annual volume provides the opportunity to spread annual fixed costs over a larger number of bales. Management and labor costs also can be reduced on a per bale basis through more complete utilization of existing plant facilities.

In their attempt to satisfy the grower and thereby succeed in obtaining higher volumes, individual gin operators have met with keen competition for the available seed cotton. Few gin plants have been built in the last five years. In fact, there has been a steady decline in gin plants, especially during the 1960's. The San Joaquin Valley contained 265 operating cotton gin plants in 1960. By 1971, that number had declined until only 212 plants remained in operation, a decrease of 20 percent.[3]

The fact that significant economies of utilization can be realized through processing larger quantities per season is well documented in cotton ginning literature. However, with the existing network of gins in the Valley, gin managers cannot be assured of obtaining the volume required to realize these economies. The next section is a discussion of the possible ways in which the cost of preparing seed cotton for commercial use can be reduced.

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[1] Many gin operators provide other services to producers during the off–season. Examples of such services include the selling of seed and supplies.

[2] A gin battery is that combination of equipment capable of producing a bale of lint cotton.

[3] U. S. Bureau of the Census, *Cotton Production in the United States: Crop of 1960* (1961) and subsequent annual issues.

Possible Solutions

If cotton ginning costs are to be reduced, ginners must increase the volume processed either by increasing output during the usual harvest season or operating for longer seasons. For technical reasons gin batteries must operate at a specific rate; otherwise, damage to fiber quality results and the producer is penalized. Therefore, ginning firms that want to provide faster ginning services (greater output per hour) must build higher capacity gin batteries. Possible cost reduction resulting from increasing output in the rate dimension represents an economies–of–scale problem and is dealt with later in this study. Emphasis in this section is placed on increasing annual gin volumes by lengthening the ginning season.

The present seasonal operating schedule offers ample opportunity for increases in operating hours either within the present ginning season or as an extension of the season. However, significant increases in gin operating hours beyond the normal harvest season would involve the storage of seed cotton before ginning. Seed cotton storage would allow the gin to operate independently of the cotton harvest, a tremendous advantage for gins faced with peak capacity limitations. Plants could operate for much longer seasons, the only constraints being the seed cotton storage facilities available and the amount of cotton obtained during the harvest season. By lengthening the operating season and increasing the volume ginned annually, total fixed cost is spread over a larger volume resulting in lower fixed cost per unit of output; and with constant variable costs per unit of output, the overall effect would be to lower average total costs. Longer ginning seasons would provide the additional benefit of shortened lint cotton storage periods. Further, many gin managers would find it easier to hire gin crews if the crews could be offered a longer work period.

With a lengthened operating season, it is essential to minimize reductions in the value of the seed and fiber due to seed cotton storage. Only a small deterioration in quality can be sustained before the price–depressing effect of lowered quality outweighs the advantages of storage. Previous research on seed cotton storage has centered around determining moisture levels at which seed cotton can be stored safely, although other factors such as temperature, humidity, and microorganisms also have been studied. Experimental techniques have included storage on pallets, on the ground in loose and baled forms, in baskets, and in specially designed buildings and warehouses. Most of the studies have concluded that seed cotton can be safely stored for varying periods of time provided reasonable constraints are levied on moisture content, temperature, and relative humidity. Moisture levels of less than 10 percent are considered low enough for safe storage, and some studies have concluded that moisture levels up to 12 percent also are acceptable.

In a 1959 survey of 47 gins in the San Joaquin Valley, Hoover noted the following distribution of moisture content in seed cotton samples taken from trailers during three periods:[1]

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[1] Marvin Hoover, *Survey Summary of Seed Cotton and Lint Cotton Moisture Content at 47 San Joaquin Valley Gins, 1959,* California Agricultural Extension Service (Shafter, 1960).

Percent of moisture	*Percent of samples*
6.0– 6.9	1.7
7.0– 7.9	12.7
8.0– 8.9	33.0
9.0– 9.9	29.7
10.0–10.9	13.6
11.0–11.9	6.8
12.0 and over	2.5
	100.0

Over three–quarters of the samples contained less than 10 percent moisture, and only 2½ percent contained over 12 percent moisture. This distribution would allow gin operators to concentrate on ginning the high–moisture cotton during the harvest season while storing the lower moisture cotton for ginning at a later date.[1]

It is apparent that seed cotton storage would not be the only fundamental change in the conventional system brought about by longer ginning seasons. Seed cotton would be sampled and classed when it was moved into storage, a process now done after ginning. The grower then would have the option of transferring title to his cotton or placing it in government loan without having to wait until after the extended ginning season. Furthermore, the cotton of individual growers would not have to be kept separate, a fact that could increase ginning speed by as much as 10 percent.[2] Seed cotton also could be blended to increase lint uniformity. Increased lint uniformity is likely to make cotton a more desirable product from the mill's standpoint.

The U. S. Department of Agriculture currently is interested in seed cotton storage as is evidenced by the seed cotton loan program. Since the 1971–72 harvest season, the Agricultural Stabilization and Conservation Service has operated a government loan program for seed cotton stored in ricks or bales.

In many other cotton producing countries, cotton is sold by growers as seed cotton. Campbell has estimated that nearly 90 percent of the cotton grown in foreign countries is sold in this manner.[3]

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[1] It is recognized that this distribution may not represent current conditions. Additional testing is needed to determine any differences caused by the current widespread use of machine harvesters.

[2] U. S. Farmer Cooperative Service, *op. cit.*, pp. 45 and 46.

[3] *Ibid*, p. iv.

The previous proposals involving extended ginning seasons through seed cotton storage are the principal components of a method of gin operation called "central ginning." This is the term used by Campbell to define a system by which gin owners receive and store enough seed cotton to supply their gins for several months a year at capacity rates.[1] Campbell has estimated that about 75 percent of the cotton grown in foreign countries is ginned by the centralized method.

Given the technical feasibility of seed cotton storage and the existing pattern of cotton production in the San Joaquin Valley, it is hypothesized that the combined cost of assembly and ginning could be significantly reduced if the ginning season were lengthened to allow for larger volumes per gin. However, the ability to increase annual volume per gin is dependent upon an increased cotton crop and/or a reduction in gin numbers. Increases in cotton production are possible, but the major effect on volume per gin will have to come through a reduction in the number of ginning facilities in the Valley. A reduced number of gins would mean a larger supply area for each gin and an increased volume per plant. This ginning system would increase assembly cost and alter storage and sampling cost. Thus, the economies of larger plant volumes must be examined in relation to the possible diseconomies of assembling seed cotton from the larger supply area required to obtain the higher volume.

FRAMEWORK OF ANALYSIS

In a competitive system the location of economic activity depends, to a considerable extent, on the relationships between costs of assembling raw materials, processing costs, and costs of distributing finished products. Plants in some industries tend to be located as near as possible to the source of their raw materials, while plants in other industries tend to be located as close as possible to their markets. These differences in industry orientation largely can be accounted for by differences in production processes and transfer costs among industries. Processes in which the raw material weight loss is considerable are likely to be located close to the raw material supply points. If the production process adds bulk or weight to the finished product, the industry tends to be market oriented. These tendencies hold if the transfer cost functions for both raw material and final product are linear or increase at a decreasing rate with distance and are equal for equivalent units of final product. Modifications can be made to these general rules to incorporate actual conditions in a given problem.

In cotton ginning the relative weights of raw materials and finished products are roughly equal.[2] However, after ginning, the bulkiness of the cotton is reduced through

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[1] *Ibid.*

[2] Cotton lint and cottonseed must be shipped to separate processing plants, whereas these products both arrive at the gin as one commodity, i.e., seed cotton. Only the trash is discarded in the ginning process.

compression of the cotton lint. Thus, the freight rates are lower per pound of lint for the processed product, and cotton gins are more economically located near their material sources. This raw material orientation results in location of cotton gins at fairly short intervals throughout the production areas.

Estimation of the optimum regional organization of cotton ginning plants involves a consideration of both the costs of assembling seed cotton from scattered production points to plant locations and the costs of ginning. Distribution costs for the processed product are not a factor in determining optimum plant locations in this study. This is because California is considered a single origin point when shipping cotton to the East Coast or for export.

The conventional economic theory underlying both assembly and processing costs has been presented by numerous writers and is not discussed here.[1] However, the analysis has benefited from several modifications to the conventional theory of the firm, and these modifications are discussed as they relate to the cotton ginning process.[2]

Plant Segmentation

Plant segmentation refers to the division of a plant into two or more units operating in parallel. Production can be varied by withdrawing each unit from operation without influencing the efficiency of the other units. Segmentation may occur in the performance of a given operation such as in the case of multiples of the same machine or may involve duplication of a whole processing line, any part of which may be made up of identical operating segments. If segmentation is present, output can be varied either by intensification on the fixed factors in one particular segment, by addition of operating segments, or by a combination of both. If rate of output is increased by the addition of identical equipment, machines, production lines, or workers performing identical tasks, which represents no intensification on fixed factors or no change in the combination of inputs used, the total cost function will tend to be linear but discontinuous.[3]

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[1] James M. Henderson and Richard E. Quandt, *Microeconomic Theory* (New York: McGraw–Hill Book Company, Inc., 1958), 291p.

Paul A. Samuelson, *Foundations of Economic Analysis* (Cambridge: Harvard University Press, 1947), 447p.

George Joseph Stigler, *The Theory of Price* (3d ed.; New York: The Macmillan Company, 1966), 355p.

[2] B. C. French, L. L. Sammet, and R.G. Bressler, Jr., "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," *Hilgardia,* Vol. 24, No. 19 (July, 1956), pp. 543–721.

Hans Brems, "A Discontinuous Cost Function," *American Economic Review,* Vol. 42, No. 4 (September, 1952), pp. 577–586.

[3] Joel Dean, *Statistical Cost Functions of Hosiery Mills* (Chicago: University of Chicago Press, 1941), p. 116.

One example of plant segmentation in cotton ginning is the use of two or more gin batteries at a single plant site. Each battery can operate separately and independently from the others. Because of the technical requirements of ginning plants, increases in processing rates can be affected only through the operation of additional batteries.

Time Dimension vs. Rate Dimension

For a plant of fixed size, variation in output is achieved by either extending the time period in which the plant operates or by increasing the rate of output within a given time period. Output variation in the rate sense results in curvilinear total cost curves. However, by varying the number of hours operated (per day, per week, or per month) while keeping rate of operation constant, the total cost curve will be linear.[1] Again, this is due to the lack of intensification on the fixed factors or changes in input proportions.

The time *vs.* rate dichotomy is important in the study of cotton ginning plants. Since the technical requirements of cotton gins severely limit the variations of ginning rates per battery in the short run, variations in total annual volume per battery must result from variation in operating hours per season. This results in a linear total cost function because of the lack of intensification on fixed factors. However, the average total cost function is curvilinear and declines as output increases until capacity output is reached.[2] Movement along the average total cost curve in the volume dimension is accomplished through variation in gin operating hours. These cost relationships for an individual plant are illustrated in Figure 2.

In the long run, scale of plant is also a variable; and the long–run average total cost curve for a given number of operating hours is derived from short–run average total cost curves. When processing can take place in seasons of varying length, it is necessary to find the least–cost combination of operating hours and operating rates for processing any desired volume. Figure 3 illustrates long–run average total cost curves for two different operating periods.

In the case of the plant average total cost function shown in Figure 2, the decreased unit cost is brought about by the greater volume that can be ginned through lengthening the number of hours ginned per time period, given a specified plant size. Average total costs shown in Figure 3 decrease because of the economies achieved as plant size is increased and length of ginning season remains fixed.

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[1] The total cost function may be discontinuous if, for example, premium wages are paid for overtime.

[2] For a given plant, capacity is defined as the maximum volume that can be processed by operation at the plant's maximum output rate during a fixed operating period.

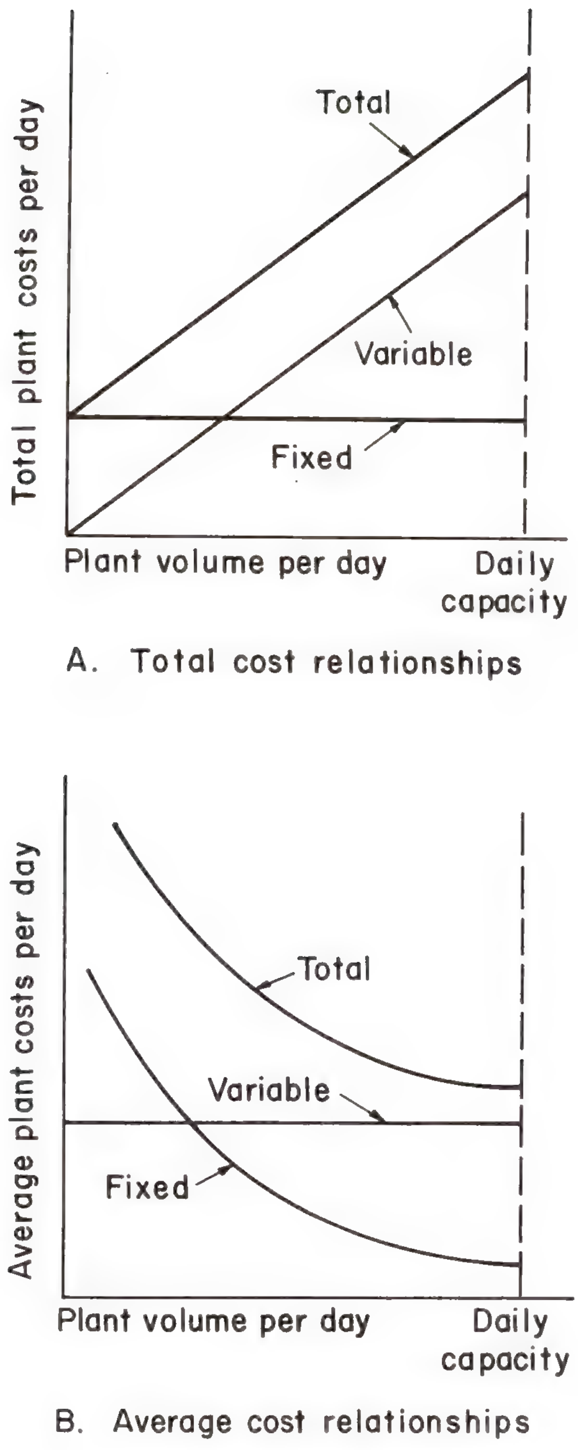

FIGURE 2. Cost Relationships for an Individual Plant in Which Rate of Output is Constant and Total Output is Increased by Operating for Longer Time Periods

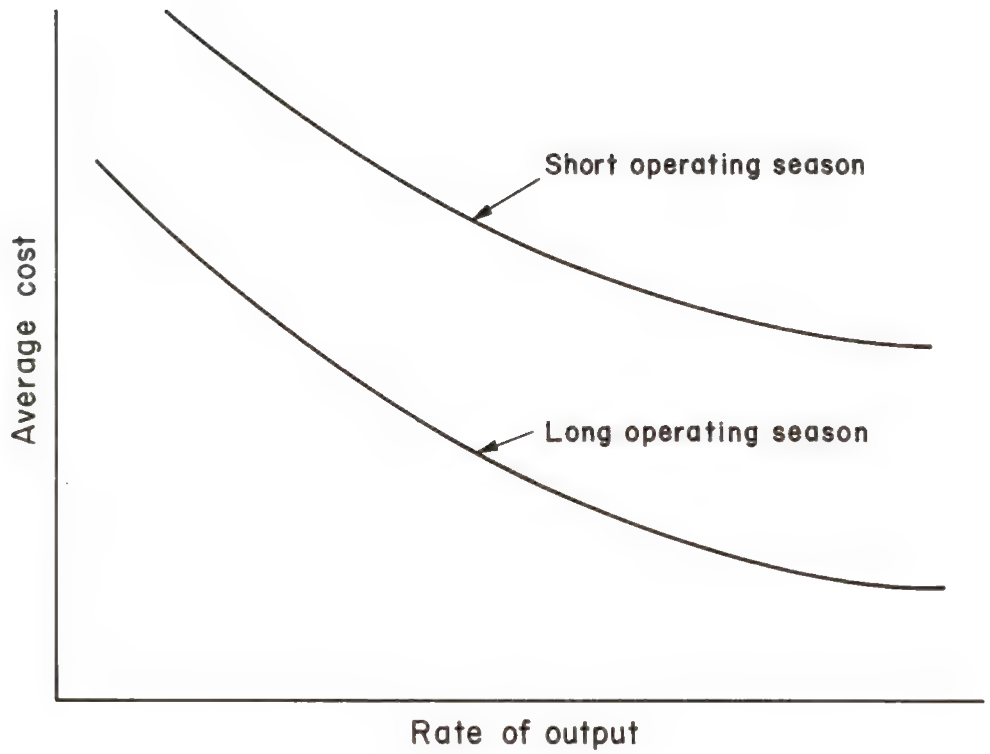

FIGURE 3. Long-Run Average Total Cost Functions for Plant Operations With Different Lengths of Seasonal Operation

Storage Costs and Storage Requirements

Storage costs consist of three basic categories: (1) the cost of moving materials into and out of storage, (2) the variable costs of keeping materials in storage, and (3) the fixed costs of owning storage buildings and equipment. These costs are determined by the following factors: (1) handling costs are largely dependent on the total volume of products stored, (2) variable costs are a function of the time–weighted average quantity of products in storage, and (3) fixed costs are determined by size of the storage facility.

Various relationships involving storage requirements are illustrated in Figure 4. In the diagram an attempt has been made to represent cotton storage requirements, both in seed and lint form. The horizontal axis is divided into 12 one–month periods. The harvest season starts at the beginning of the first month, and the total quantity harvested increases with time at a decreasing rate until the harvest is over at the end of month 3 (Figure 4, line OAB). The quantity of lint cotton consumed is expected to be uniform throughout the 12–month period and equals the total year's harvest––line OEJH.[1] To meet the expected consumption rate, several processing (ginning) schedules are possible. Two of these schedules are shown in Figure 4. A six–month uniform rate processing schedule is represented by line OCF. A plant which operates at a uniform rate for 11 months is shown by line ODG. Since, for these examples, cotton would be harvested at a faster rate than either production rate, it would be necessary to store any seed cotton that could not be ginned immediately after harvest. Further, the consumption rate is lower than either production schedule, thus requiring storage of any lint cotton not immediately consumed after ginning. The maximum storage requirement for either seed or lint cotton storage in relation to the given processing schedules is also shown in Figure 4. With processing schedule OCF, a maximum seed cotton storage of AC and lint cotton storage of FE is required. With schedule ODG, the maximum storage requirements increase to BD in the case of seed cotton and decrease to GJ in the case of cotton lint.

THE EMPIRICAL MODEL

The empirical model used in this study to estimate the number, size, and location of cotton gins required to minimize the total costs of assembling and processing cotton in the San Joaquin Valley in 1975 is based on a method developed by Stollsteimer.[2] The method employs a variation of the linear programming transportation model. The model as applied to the present problem can be stated as follows:

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[1] No carry–in or carry–out is assumed.

[2] John F. Stollsteimer, "The Effect of Technical Change and Output Expansion on the Optimum Number, Size and Location of Pear Marketing Facilities in a California Pear Producing Region" (unpublished Ph.D. dissertation, University of California, Berkeley, 1961), 250p.

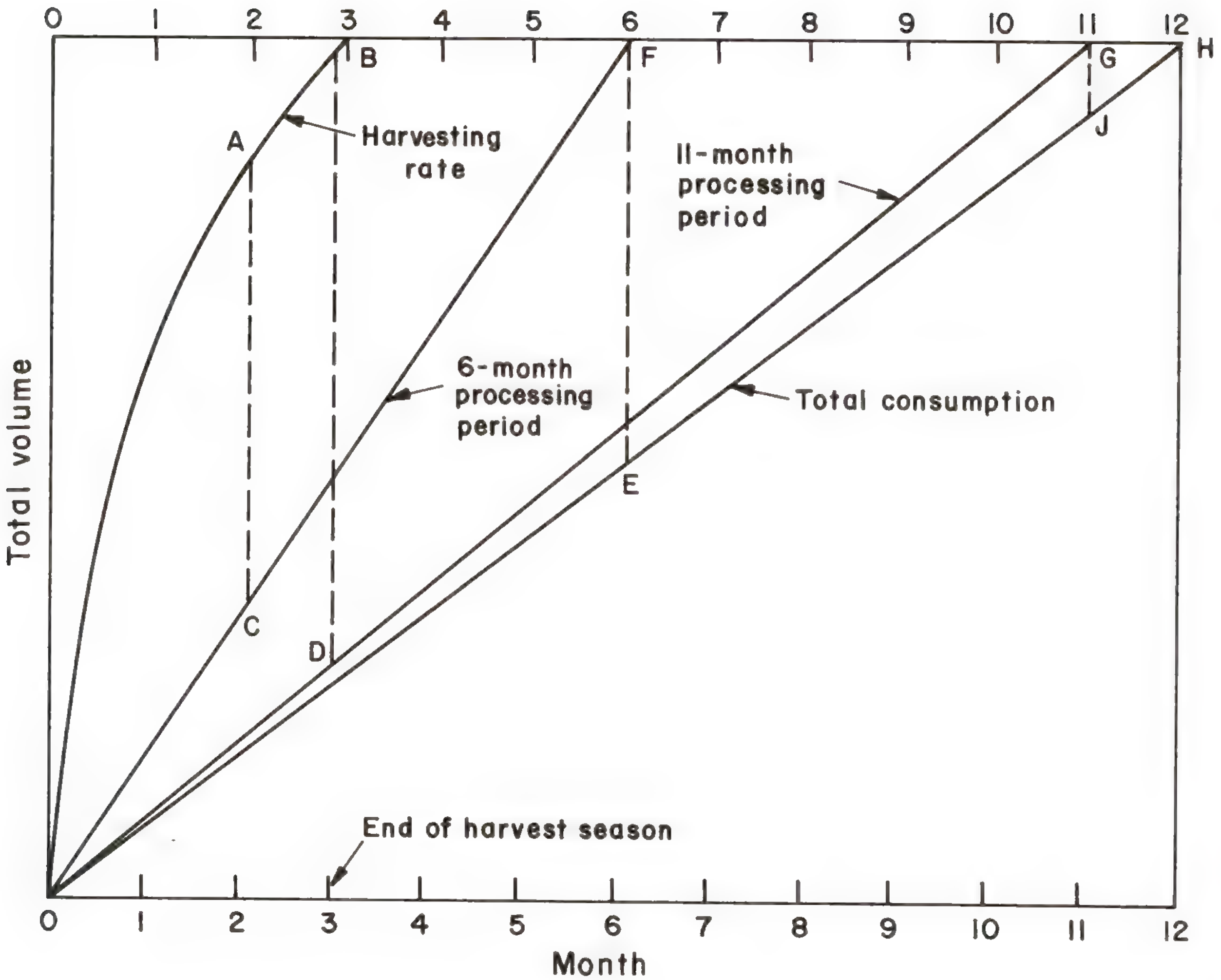

FIGURE 4. Cotton Storage Requirements with 6-and 11-Month Ginning Schedules

Given I cotton production sites, each of which produces a quantity X_i of cotton to be assembled and ginned at one of L possible plant location sites located within the cotton producing region at points adjacent to the existing transportation network, what is the total number and location of plants and capacity of each plant which will minimize the total cost of assembly and ginning the total quantity of cotton produced in the region? Minimize

$$\underset{(J,L_k)}{TC} = \sum_{j=1}^{J} P_j X_j \mid L_k + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \mid L_k \qquad (1)$$

with respect to plant numbers ($J \leqslant L$) and locational pattern

$$L_k = 1 \ldots \binom{L}{J}$$

subject to

$$\sum_{j=1}^{J} X_{ij} = X_i$$

which equals quantity of raw material available at origin i per production period

$$\sum_{i=1}^{I} X_{ij} = X_j$$

which equals quantity of material processed at plant J per production period, and

$$\sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} = X$$

which equals total quantity of raw material produced and processed

$$X_{ij}, X_j \geqslant 0 \text{ and } C_{ij} > 0$$

where

TC = total processing and assembly cost

P_j = unit processing costs in plant j ($j = 1 \ldots J \leq L$) located at L_j

X_{ij} = quantity of raw material shipped from origin i to plant j located at L_j

C_{ij} = unit cost of shipping material from origin i to plant j located with respect to L_j

L_k = one locational pattern for J plants among the $\binom{L}{J}$ possible combinations of locations for J plants given L possible locations

and

L_j = specific location for an individual plant ($j = 1 \ldots J$).

The model requires the use of a linear long–run plant cost function with a positive intercept and can be used in any one of the following four situations:[1]

1. Economies of scale in plant operation with plant costs independent of plant location.

2. Economies of scale in plant operation with plant costs that vary with plant location.

3. No economies of scale in plant operation with plant costs independent of plant location.

4. No economies of scale in plant operation with plant costs dependent upon plant location.

The specific version used in this study is selected after all cost functions have been derived.

As an illustration of the model, Figure 5 shows the effect of increasing numbers of plants on both total assembly costs and total plant costs. Total assembly costs (curve $\overline{TAC}$) decrease as plant numbers are increased because the size of the individual plant

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[1] For a partial list of studies supporting the existence of linear plant cost functions in cotton ginning, see footnote 2, *supra*, p. 2; see, also, W. F. Paulson, *Cost and Profit of Ginning Cotton in Texas*, Texas Agricultural Experiment Station Bulletin 606 (College Station, 1942), pp. 13-17.

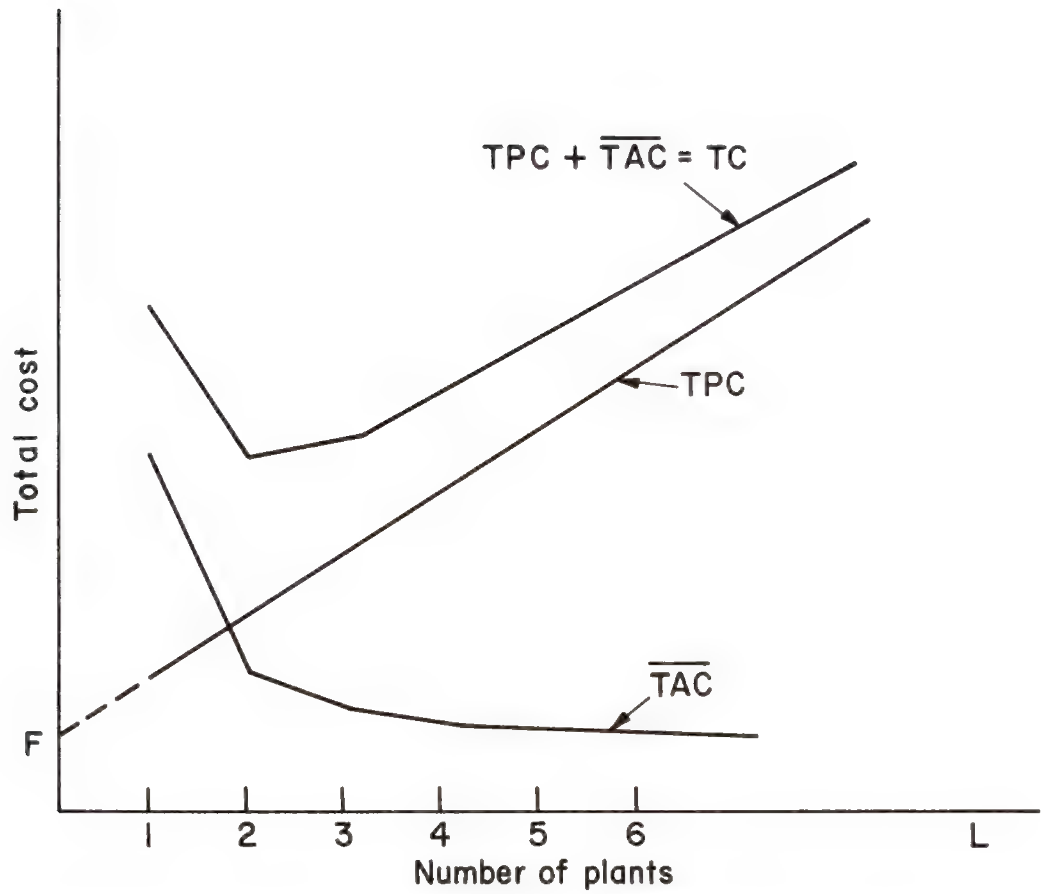

FIGURE 5. Minimized Total Assembly and Plant Costs for a Fixed Quantity of Product

supply areas and thus the assembly distances are reduced. When J plants are involved out of a possible total of L, there exists a total of $\binom{L}{J}$ possible combinations of locations for the J plants. One of these combinations gives minimum total assembly cost for each given number of plants. Curve $\overline{TAC}$ represents the minimum total assembly cost, considering all possible combinations of plant locations, for each given number of plants. In effect, the curve $\overline{TAC}$ is an envelope curve for all other curves representing assembly cost for less efficient combinations of plant locations.

Curve TPC (Figure 5) represents the effect of plant numbers on total plant costs. Given a fixed amount of material to be processed and a linear long–run plant total cost function having a positive intercept, the TPC curve increases as the number of plants increases by the intercept value of the plant cost function.[1]

Both assembly and plant costs are added as shown in curve TC (Figure 5). The relative slopes of the $\overline{TAC}$ and TPC curve determine the minimum point of the combined curve. In Figure 5 this minimum point is with two plants. With two plants located at the optimum locations, the industry will minimize its total average costs of assembly and processing.

The Stollsteimer model is adaptable to any pattern of production and processing locations and outputs. However, a solution based on a specified pattern of origins and quantities of output and potential plant sites is unique to that pattern. If the spatial structure should change, the solution procedure would have to be repeated.

Stollsteimer originally applied his model to the problem of specifying the optimum size, number, and location of pear packing plants in Lake County, California.[2] The model has since been applied to a number of problems, e.g., in a study on orange packinghouses in California by Siebert[3] (here a plant capacity restriction was added which allowed for more than one plant at each location) and in one by Mathia and King on sweet potato processing in North Carolina.[4] Courtney used the model to minimize the cost of processing

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[1] The intercept value can be interpreted as the minimum average annual long–run cost of establishing and maintaining a plant; see Stollsteimer, "A Working Model for Plant Numbers and Locations," *Journal of Farm Economics,* Vol. 45, No. 3 (August, 1963), p. 636.

[2] *Idem,* "The Effect of Technical Change and Output. . . ."

[3] Jerome Bernard Siebert, "Long Range Adjustment of Orange Packinghouses in Central California: A Consideration of the Optimum Number, Size and Location of Packing Facilities" (unpublished Ph.D. dissertation, University of California, Berkeley, 1964), 201p.

[4] Gene A. Mathia and Richard A. King, *Planning Data for the Sweet Potato Industry, Part 3: Selection of the Optimum Number, Size, and Location of Processing Plants in Eastern North Carolina,* North Carolina Agricultural Experiment Station, Information Series No. 97 (Raleigh, 1962), 75p.

and distribution for feed manufacturing plants.[1] Logan and King did a more comprehensive study in the case of beef slaughtering plants.[2] In their study both the costs of assembly and distribution were important. The transshipment model of linear programming was used to simultaneously consider the costs of assembly, processing, and distribution.

To utilize the previous model in solving the present problem, the following four categories of data are needed:

1. Estimated volume of seed cotton to be assembled from each origin.

2. Specification of potential plant sites within the production area.

3. A transportation cost matrix that specifies the unit cost of hauling from each production origin to each potential plant site.

4. A plant cost function which determines the cost of processing a fixed quantity of material.

FIELD HANDLING AND ASSEMBLY

Previous research relating to cotton assembly operations primarily has been concerned with problems involved in transporting cotton in loose form. With increased hauling distances and the possibility of cotton storage prior to ginning, alternative field handling and assembly techniques are required.

Several alternative methods for field handling and assembly of cotton have been proposed. Campbell has suggested a system in which receiving stations would be used as intermediate transfer points between field and gin.[3] The receiving stations would be equipped with unloading, cleaning, and extraction equipment in addition to weighing, sampling, and baling facilities. Cotton would be hauled to a receiving station in loose form and then conditioned and baled in large wastepaper balers (1,500–pound bales) before being hauled to the central gin site. The bales of seed cotton would be transported to the gin on flatbed trucks without the high expense and risk associated with loose seed cotton assembly. This method allows continuous gin operation for a longer period than the harvest season and storage of cotton prior to ginning. A substantial cost savings was found when this system involving central ginning combined with receiving stations was

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[1] R. H. Courtney, "Efficient Organization in California's Central Valley Feed Manufacturing Industry" (unpublished Ph.D. dissertation, University of California, Berkeley, 1968), 229p.

[2] S. H. Logan and G. A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," *Hilgardia*, Vol. 36, No. 4 (December, 1964), pp. 139-188.

[3] U. S. Farmer Cooperative Service, *op. cit.*

compared to conventional methods. A second system, also proposed by Campbell, involves the use of in–field hay balers.[1] Balers were to be either mounted on harvesters in place of conventional baskets or be pulled behind conventional harvesters. Seed cotton baling using hay balers had been done before in experimental projects, but balers had never been used in conjunction with the cotton harvester.[2] The technique assumed that baled seed cotton would be hauled to the gin like baled hay; receiving stations would not be required. Campbell concluded that total costs for assembly and ginning with central ginning and no receiving stations would be $4.38 per bale less than if receiving stations were used.

Still a third method of cotton handling has been proposed by Smith.[3] Storage and handling tests were conducted on cotton stored in ricks in the field. Ricks were formed by dumping seed cotton from harvesters into a movable form. The cotton was then compacted and the form was moved away, leaving a freestanding rick. Smith found that these techniques resulted in "greater utilization of harvesters, trailers, and gins while additional costs would be incurred in stacking and loading operations."[4] Estimated net savings (through the ginning stage) for the area studied ranged from $10.99 to $19.93 per bale. However, this method of handling seed cotton would not solve the distance problem in a central ginning system since the cotton would still be hauled in loose form——an expensive means of transport for long distances. Furthermore, it is likely that cotton stored for long periods in the open would decrease in value. This would be especially true in the San Joaquin Valley with its wet and foggy late fall and winter weather.

The technique using in–field hay balers presents certain advantages over other systems. In-field baling can be the basis for the seed cotton handling modifications necessary for long–distance hauls and for warehouse storage. Seed cotton transport is more economical if seed cotton is baled at the field rather than hauled in trailers in loose form. Using the assembly technique discussed later, the cost of hauling hay–bale size cotton bales a distance of 10 miles would be $1.60 less per lint–equivalent bale than the cost of hauling loose seed cotton in trailers.[5]

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[1] *Idem, Reducing Cooperative Cotton Ginning Costs in Oklahoma: Three Suggested Ways,* by John D. Campbell, FCS Research Report No. 9 (1970), 35p.

[2] Seed cotton baling using hay balers has been attempted successfully at least twice before. For 10 years (1949–1959), some cotton growers in Nevada baled seed cotton with a three–tie hay baler and hauled it 265 miles to the nearest gin in California. Metcalf also experimented with the use of hay balers for baling seed cotton; see, also, Virgil Alonzo Metcalf, "Alternative Marketing Systems for Cotton Involving Delayed Ginning Through Various Storage Techniques" (unpublished Ph.D. dissertation, University of Missouri, Columbia, 1964), 163p., and G. H. Abernathy and J. M. Williams, "Baling Seed Cotton for Storage and Handling," *Transactions of the ASAE,* Vol. 4, No. 2 (1961), pp. 182–184.

[3] Milton Smith, *A Feasibility Study of Field Storage and Handling of Seed Cotton,* Texas Technical University, Department of Industrial Engineering (Lubbock, 1971).

[4] *Ibid.*

[5] The loose seed cotton would be hauled in six–bale trailers used nine times per year (Table 16, *infra,* p. 73). If the baled seed cotton were not loaded by a power–operated loader, the cost saving would be reduced by 75 cents per bale.

The cost of baling is not accounted for when comparing the two transport costs, but the baling is necessary for economical utilization of warehouse space.[1] Total warehouse space taken up by baled seed cotton would be much less than the space taken up by an equivalent quantity of loose seed cotton. One storage study done by Looney, Wilmot, Holder, and Cable showed that, in most cases, the cost of loose seed cotton storage more than offset the savings brought about by ginning greater volumes.[2] A further advantage to the baling concept is that the harvesting operation no longer need be delayed for lack of trailers. Savings of up to 25 percent in harvesting efficiency have been estimated when harvesters are not required to wait for available containers.

Two techniques have been suggested by Campbell for baling seed cotton in the field. The technique using harvester–mounted balers was discussed above. More recently, Campbell proposed a second system in which seed cotton would be baled in hay balers stationed at the turn row.[3] This system is the most likely to solve the problems associated with seed cotton handling, assembly, and storage. This method has several advantages over attaching the baler to the harvester:

1. Hay balers stationed alongside the field require no modification of conventional harvesting equipment and little modification of baling equipment.

2. A baler and/or pickup trailer towed behind the harvester would greatly decrease the maneuverability of the harvester.

3. It would be much more difficult to stack bales dropped in the field than to stack them from a stationary baler.

4. Harvesters with mounted balers would reduce the producer's flexibility. After harvesters were modified, cotton could be harvested only in baled form.

For the purpose of this study, interviews were conducted with cotton growers, gin managers, warehouse managers, marketing personnel, and equipment company personnel in the San Joaquin Valley. Their ideas and opinions are an integral part of the slightly modified version of Campbell's system discussed in this study.

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[1] For a discussion on the necessity for storage of seed cotton in warehouses, see *infra*, p. 36.

[2] U. S. Economic Research Service, *Cost of Storing Seed Cotton*, by Zolon M. Looney *et al.*, Marketing Research Report No. 712 (1971), 23p.

[3] U. S. Farmer Cooperative Service, "A Proposed System for Ginning and Handling Cotton Cooperatively," by John D. Campbell (1971), preliminary draft.

Baling and Stacking Operation

Using the system proposed in this study, seed cotton baling would not require that existing harvesting equipment be modified. Harvesters would dump seed cotton into a specially designed portable feeder bin stationed at the turn row. The feeder bin would be equipped with straight sides and a movable floor. Feed control cylinders with self–cleaning fingers on one end of the bin would feed seed cotton at a controlled rate into the portable hay baler. Newly formed bales would be dropped into an automatic bale wagon that would stack the bales alongside the road ready to be loaded onto trucks. The whole unit––feeder bin, baler, and bale wagon––could be moved from field to field or from farm to farm.

The baler should be capable of producing a three–tie bale, 16″ x 23″ x 46″. Several factors justify this bale size: (1) seed cotton bales may be difficult to hold intact with only two ties, and three ties may be necessary to eliminate excessive sloughing; (2) stacks of these bales correspond closely to legal truck widths; (3) the large three–tie bales increase handling efficiency; and (4) bales of the size formed from a large wastepaper baler would be too large to allow for adequate drying or humidifying of bales in storage.

Bale weight will vary depending on the density for which the baler is set but will probably range between 150–175 pounds. In this study the more conservative estimate of 150 pounds was assumed. With that weight and the previously specified bale dimensions, density would be 15.3 pounds per cubic foot. Since approximately 1,500 pounds of machine–picked seed cotton is required to yield one 500–pound bale of lint, it would take 10 seed cotton bales to make the equivalent of one 500–pound lint bale.[1]

In interviews conducted for this phase of the study, it became apparent that various modifications and extensions are likely as the above system is put into practice. Balers might be adapted so that bales would have rounded corners. This would lessen the chance of sloughing from bale edges. The rounded corners would also leave air channels when the bales were stacked which would be helpful in drying or humidifying the baled seed cotton prior to ginning. It might be necessary to reduce the density of the seed cotton bale to safeguard against possible seed damage, although studies have shown that compression of seed cotton to 20 pounds per cubic foot does not result in seed deterioration under proper moisture conditions.[2] Balers might also be designed to be of relatively low capacity since high–capacity balers would not be required. Bale wagons also would be smaller capacity than present ones and would be specially adapted to operate while in a stationary position. A modified feeder bin for seed cotton might also be practical. There are probably other modifications possible, most of which will not be developed until the system is in widespread use.

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[1] On the average, the 1,500 pounds of seed cotton includes approximately 800 pounds of seed and 200 pounds of trash.

[2] See, for example, Lambert H. Wilkes and J. W. Sorenson, Jr., *Effect of Field Storage and Handling on Seed and Lint Quality,* Presented at the Western Cotton Production Conference, Lubbock Texas, March 7 and 8, 1973, p. 5.

Baling and Stacking Costs

Since baling seed cotton in the field is a relatively new idea, no actual cost data are available. However, it was possible to synthesize these costs based on information obtained from equipment companies handling similar types of equipment and from standard accounting practices. Costs were developed for an operating unit consisting of feeder bin, baler, and automatic bale wagon.

The cost of a specially designed 20–foot feeder bin was estimated to be $4,000. A reconditioned three–tie baler was estimated to cost $3,500, about half the cost of a new baler. These two items represent the only fixed investments required for each baling unit. Total annual costs associated with this investment came to $1,350 (Table 2).

Variable costs included fuel, wire, and the charge for accumulating and stacking seed cotton bales (Table 2). It was specified that the accumulating and stacking operation would be done by custom operators. This specification was based on several factors. Most important was the high cost of ownership of an automatic three–tie hay bale accumulator, about $14,000 for a new machine. Since this type of machine is relatively new, there are very few used ones available. Hand stacking is another alternative to the use of custom–machine operators, but labor shortages for this type of labor would probably restrict its use in this stacking method. However, many of the owners of bale accumulators are custom operators during the haying season. Since the haying season is usually over by October 1, these operators would be free to work for cotton producers during the cotton harvesting season. Custom accumulating and stacking is expected to cost 10 cents per seed cotton bale. This is the rate now charged for hay bales, and it is anticipated that the same rate would apply to cotton bales. This equals a cost of $1.00 per lint bale, using the 10–to–1 conversion factor.

To calculate total variable costs and total costs per bale, it was necessary to estimate the average annual volume to be processed by each baling unit (feeder wagon, baler, and stacker). The capacity of the baling unit is determined in part by the hourly capacity of the baler itself. An average hay baler will bale 10 tons or 13–1/3 lint–equivalent bales per hour. A two–row, picker–type harvester can pick approximately two lint–equivalent bales per hour with yields of 1–1/2 bales per acre. One baling unit could, therefore, accommodate at least six harvesters. However, most growers do not have ample acreage to profitably use this many harvesters. Therefore, in this study it was estimated that three harvesters would supply one baling unit. Agricultural Extension personnel provided the data necessary to estimate an average annual volume per harvester of 325 lint–equivalent bales in the San Joaquin Valley.[1] If the baling unit were coupled with three harvesters, it could process the equivalent of 975 lint bales per season.

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[1] Since in the system discussed here no harvesting time would be wasted waiting for seed cotton trailers, it is possible that a harvester could average over 325 bales per year.

TABLE 2

Estimated Investment Requirements, Annual Fixed and Variable Costs, and Costs Per Lint Bale for In-Field Baling and Stacking of Seed Cotton Bales[a] Using Portable Field Baling Unit San Joaquin Valley, California, 1971

	Estimated costs		
	dollars		
Investment			
Feeder wagon[b]	4,000		
Baler[c]	3,500		
	dollars per year		
Fixed costs			
Depreciation[d]	750		
Property tax[e]	131		
Insurance[f]	75		
Interest[g]	244		
Repairs[h]	150		
Total		1,350	
Variable costs			
Fuel[i]	203		
Wire[j]	585		
Accumulate and stack bales[k]	975		
Total		1,763	
Total fixed and variable costs			3,113
Annual volume per baling unit in lint bales[l]		975	
Total cost per lint bale		$ 3.19	

a/ Ten seed cotton bales are assumed to contain enough cotton to produce one lint cotton bale.

b/ Specially designed cotton feeder wagon.

c/ Small capacity three-tie reconditioned baler.

d/ Ten-year life, straight-line depreciation schedule.

e/ 1-3/4 percent of total investment.

f/ 1 percent of total investment.

g/ 6-1/2 percent of one-half total investment.

h/ 2 percent of total investment.

i/ Based on 30 nine-hour days at 75 cents per hour.

j/ 60 cents per lint bale, 6 cents per seed cotton bale.

k/ $1.00 per lint bale for custom operator to accumulate and stack bales.

l/ Based on three harvesters, each harvesting 325 bales annually.

Source: Calculated.

Using this volume, wire cost would be $585 and custom work would cost $975. Total variable cost is $1,763. With a total annual cost of $3,113 and an annual volume of 975 bales, the baling and stacking operation would cost $3.19 per bale (Table 2). Baling cost is discussed further when costs of the optimum system are compared to the costs incurred under the present system.

Transport Operation and Cost

One of the principal benefits of in–field baling is the ease with which seed cotton can be assembled. As indicated previously, it is both more convenient and less expensive to haul seed cotton baled rather than in loose form. This becomes especially true as hauling distance is increased.

Baled seed cotton can be transported in the same manner as hay bales. One truck–tractor with two 28–foot flatbed trailers attached can haul at least 270 bales of seed cotton or the equivalent of 27 bales of lint. Loading can be performed either by hand or mechanically. It would be preferable to have an automatic loading system that can take advantage of the roadside stacking already accomplished by the automatic bale wagon. Unloading would be performed by a clamp truck at the gin site.

The California Public Utilities Commission publishes rate tariffs for the minimum rate that can be charged for transporting certain agricultural commodities in bulk within the state of California by for–hire highway carriers. No tariff is published for hauling cotton bales of any type. However, one such tariff, 14–A, is published for loading and hauling hay fodder carried in machine–pressed bales which are very similar in size and weight to seed cotton bales. The tariff is published in cents per 100 pounds for distances up to 525 miles and for loads of 0–20,000 pounds, 20,000–40,000 pounds, and 40,000 pounds or more. A truck–tractor and trailer combination, as previously specified, will typically have a maximum legal payload of slightly over 51,000 pounds. If each seed cotton bale is estimated to weigh 150 pounds and if two flatbed 28–foot trailers can haul 270 seed cotton bales, then 40,500 pounds can be carried on each load.[1] The rates for a minimum load of 40,000 pounds (the cheapest on a per unit basis) were, therefore, the rates used in this project for the assembly of seed cotton bales.

In Table 3 the 40,000–pound minimum load weight schedule is used for distances up to 220 miles. All values are for ten 150–pound bales of seed cotton or the equivalent of 500 pounds of lint cotton. This tariff schedule was used in calculating the assembly cost matrix discussed later. The cost of loading bales onto the truck is included in the tariff schedule unless a power–operated loader is not used. The schedule allows an additional 5 cents charge per 100 pounds or 75 cents per 500 pounds of lint cotton for handloading. This charge is considered again in a later section where the costs of the least–cost solution are compared to those of the present system.

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[1] If a heavier bale is used, even fewer bales would be required for a 40,000–pound minimum load.

TABLE 3

Minimum Hauling Rates for Seed Cotton in 150-Pound Bales with a Minimum Load Weight of 40,000 Pounds[a/]
San Joaquin Valley, California, 1971

Miles		Hauling rates
Over	But not over	Cost per 500 pounds of lint[b/]
		dollars
0	3	1.80
3	5	2.03
5	10	2.18
10	15	2.33
15	20	2.48
20	25	2.70
25	30	2.85
30	35	3.00
35	40	3.15
40	45	3.45
45	50	3.60
50	60	3.90
60	70	4.05
70	80	4.35
80	90	4.50
90	100	4.65
100	110	4.80
110	120	4.95
120	130	5.10
130	140	5.25
140	150	5.40
150	160	5.55
160	170	5.70
170	180	5.85
180	190	6.15
190	200	6.45
200	220	6.90

a/ When loading is not performed by a power-operated loader, an additional charge of 5 cents per 100 pounds (75 cents per 500 pounds of lint cotton) is assessed.

b/ Ten 150-pound seed cotton bales are equivalent to one 500-pound lint cotton bale.

Source: California, Public Utilities Commission, "Decision No. 7529: Before the Public Utilities Commission, State of California, Minimum Tariff 14-A, Effective May 16, 1971."

STORAGE—SEED COTTON AND LINT COTTON

Three categories of cost are involved in cotton storage—receiving or handling costs, in–storage variable costs, and fixed costs associated with ownership of the storage facility. To estimate these costs, it was first necessary to specify the product movement into and out of cotton storage facilities for a series of model gin plants.

Storage requirements are dependent upon both the rate of plant operation and the length of time the plant is operated. In this study gin plant models of 7½–, 15–, 22½–, 30–, 37½–, 45–, 60–, 75– and 90–bales–per–hour capacity, manufacturer's rating, were chosen. Storage facilities were designed to operate in conjunction with each plant model. Three seasonal lengths were chosen for study—6 months, 9 months, and 11 months. Since the normal harvest season is only two to three months long, all of the operating periods chosen would require the storage of seed cotton. Table 4 shows the cotton volume handled annually by each plant model for each season length. Additional detail is contained in the section on ginning cost.

Process Description

The cotton storage operation described below was originally proposed by Campbell.[1] However, since the original operation applied to machine–stripped cotton, various modifications were necessary for the machine–picked cotton in the San Joaquin Valley. These modifications have been incorporated into the present storage operation discussed below.

Figure 6 is a physical flow diagram for the seed cotton bale as it moves from the unloading stage to the seed cotton storage stage. When a truck arrives at the storage and ginning facility, the load is weighed. Clamp trucks unload and stack the bales in a temporary storage area. Next, the moisture test is conducted using an electronic sensing probe. Tests would be made on a sample from each truckload. Seed cotton samples are then taken either by insertion of a probe or by breaking open random bales. Further research and experimentation are necessary to perfect the techniques utilized in the sampling stage. Seed cotton samples are ginned on a small laboratory gin located at the site. The seed cotton samples enable the ginner to predict the lint turnout. The analysis includes another test for moisture content for safe storage and so that accurate lint cotton weights can be determined.[2] The remaining classification for grade, staple length, strength, and micronaire is determined at the government classing stations as is now the practice.[3] The results of the sample analysis are used as the basis for paying the grower for his stored seed cotton.

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[1] U. S. Farmer Cooperative Service, *Central Cost Ginning, Comparative Costs . . .*; see, also, *idem*, "A Proposed System for Ginning. . . ."

[2] For a further report on sampling and analysis, see *idem*, *Central Cotton Ginning, Comparative Costs. . . .*

[3] The Cotton Division of the Agricultural Marketing Service, U. S. Department of Agriculture, presently classifies cotton.

TABLE 4

Annual Volume of Cotton Handled in Model Ginning Plants, by Length of Season[a/]
San Joaquin Valley, California, 1971

Plant capacity	Length of season		
	6 months	9 months	11 months
bales per hour	number of 500-pound bales		
7½	12,528	18,792	22,968
15	25,056	37,584	45,936
22½	37,388	56,082	68,546
30	49,916	74,874	91,514
37½	62,444	93,664	114,482
45	74,972	112,456	137,450
60	99,832	149,746	183,028
75	124,888	187,330	228,966
90	149,748	224,620	274,544
Hours of operation	3,088	3,132	3,828
Actual hours of processing time[b/]	1,958	2,936	3,589

a/ Operating specifications: (1) plants operate two 8-hour shifts per day, 5 days per week; (2) one-half hour per shift is devoted solely to clean up and crew rest; (3) monthly periods are assumed to equal 4.35 weeks; and (4) productive capacity equals 85 percent of stated plant capacity.

b/ Actual processing time does not include clean-up periods and is rounded to nearest hour.

Source: Calculated.

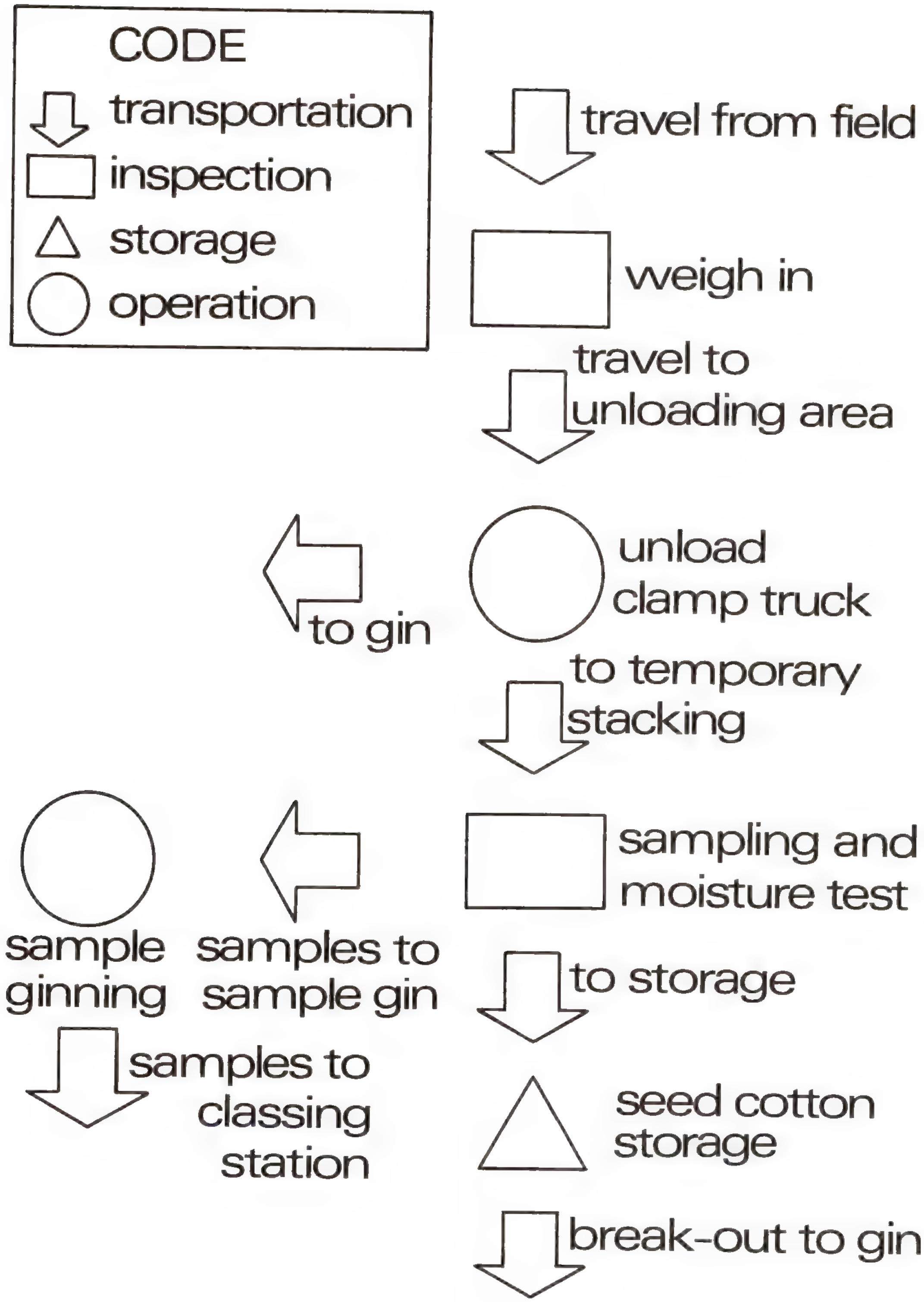

FIGURE 6. Process Flow--Seed Cotton Receiving and Storage

After samples are taken, the bales are transported (via clamp trucks) to the storage warehouses and stored there until they are broken out for ginning. Each lot or load is identified and labeled to coincide with the sample(s) taken from it. These designations, as well as the results of the sample analysis, are used in the blending process just before the ginning stage. Some of the seed cotton would not need to be sampled or stored but would be ginned immediately to keep the gin operating at full capacity during the receiving period. This cotton would include bales too wet to be safely stored. Ginned cotton is either shipped soon after ginning or stored in the warehouses as these buildings are emptied of seed cotton.

Seed Cotton Flow

Using information obtained from the U. S. Bureau of the Census, the average percentage (using a three–year average, 1969–1971) of the total San Joaquin Valley crop ginned during each two–week period of the ginning season was estimated.[1]

For the purposes of this study, it was considered that these ginning rates coincided with seed cotton receiving rates. This is a reasonable assumption since, under present conditions, cotton seldom remains on the gin yard for more than two days before it is ginned.

On the basis of these derived seed cotton receiving rates, a series of operating periods for the receiving, storing, and ginning operations was developed as follows:

Operation	*Beginning*	*Ending*	*Hours per day*	*Hours per shift*	*Days per week*
Ginning	October 1	Varies	16	8	5
Receiving	September 15	October 1	8	8	5
	October 1	November 14	16	8	7
	November 14	January 1	8	8	5
Storing	September 15	October 1	8	8	5
	October 1	November 14	16	8	7
	November 14	December 1	8	8	5

Specification of hours per day, hours per shift, and days per week is discussed further in the section on ginning.

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[1] U. S. Bureau of the Census, *op. cit.*

It is specified that, during the ginning and receiving season, the incoming cotton is allocated so that the gin operates at capacity and the remainder is stored. This specification is made for two reasons. First, there usually would be some cotton that was too wet to store safely; this cotton would go directly to the gin battery. Second, there appears to be little justification to incur the costs of sampling and storage on seed cotton that the gin could process upon arrival. By December 1, the storing operation would be over. Cotton would be received after that date at a rate less than the daily ginning rate and would be ginned upon arrival. Stored seed cotton would provide the additional supplies needed to keep the gin plant operating at full capacity.

Using the percentage received in each two–week period, it was then possible to calculate the equivalent bales of lint cotton received, stored, and ginned per shift during each two–week period for each gin model.[1] Table 5 shows these figures for the 7½–bale–per–hour model.

Peak storage requirements for each model gin were calculated by adding the quantities stored in each two–week period. Table 6 shows the maximum number of equivalent bales of lint cotton that would have to be stored at any one time for each model gin.

It should be noted that the preceding assumptions concerning seed cotton flows and storage requirements are approximations. Given the irregularity of the cotton harvesting season, it is unlikely that a gin manager could expect to receive seed cotton at an even flow during each two–week period of the harvest season as described above. Nevertheless, an attempt has been made to set up a representative model for these flows.

Investment Requirements

Receiving.––Receiving operations consist of weighing, unloading, moisture testing, sampling, sample ginning, and storage placement.

For the weighing of the loaded truck trailers, a 70–foot scale is used. The cost of this type of scale is included in the cost of the gin plant. Clamp trucks rented during the receiving season are used to unload seed cotton bales and to place them in storage. Rental rates for 3,000–pound capacity trucks are discussed later in the section on variable costs. Moisture testing is done by an electronic sensing probe that can be operated by one man.

The sample ginning process requires a gin of laboratory size. A laboratory gin capable of cleaning, conditioning, and ginning fifty 1,000–gram (2.2 pounds) samples per hour

[1] In actuality, more cotton would probably be received in day shifts than night shifts. However, this could be offset by having the night crew spend most of its time storing cotton received during the day.

TABLE 5

Volume of Cotton Received, Stored, and Ginned During the Receiving Season for a 7½-Bale-Per-Hour Model Ginning Plant Operating Two Shifts Per Day, by Length of Season a/
San Joaquin Valley, California, 1971

Length of season and percentage of total season cotton receipts obtained during two-week period ending: b/	Total volume of cotton received c/	Daily volume of cotton			
		Receipts per shift d/	Ginned per shift d/	Stored per shift d/	Ginned without storage d/
	bales				
6 months					
October 1; 1 percent	125	13	0	13	0
October 18; 15 percent	1,879	67	48	33	96
November 1; 39 percent	4,886	174	48	140	96
November 14; 27 percent	3,383	121	48	87	96
December 1; 12 percent	1,503	150	48	54	96
December 13; 4 percent	501	50	48	0	50
January 1; 2 percent	251	25	48	0	25
Total received: 12,528					
9 months					
October 1; 1 percent	188	19	0	19	0
October 18; 15 percent	2,819	101	48	66	96
November 1; 39 percent	7,329	262	48	227	96
November 14; 27 percent	5,074	181	48	147	96
December 1; 12 percent	2,255	226	48	130	96
December 13; 4 percent	752	75	48	0	75
January 1; 2 percent	376	38	48	0	38
Total received: 18,792					
11 months					
October 1; 1 percent	230	23	0	23	0
October 18; 15 percent	3,445	123	48	89	96
November 1; 39 percent	8,958	320	48	285	96
November 14; 27 percent	6,201	222	48	187	96
December 1, 12 percent	2,756	276	48	180	96
December 13; 4 percent	919	92	48	0	92
January 1; 2 percent	459	46	48	0	46
Total received: 22,968					

a/ All values are in lint bales, equivalent to 1,500 pounds of seed cotton.

b/ Based on an average of ginnings in the San Joaquin Valley for 1969, 1970, and 1971.

c/ Number of bales rounded to integers.

d/ Values are rounded to integers. Equivalent data for 15-, 22½-, 30-, 37½-, 45-, 60-, 75-, and 90-bale-per-hour gins can be computed by multiplying by 2, 3, 4, 5, 6, 8, 10, and 12, respectively.

Source: Calculated.

TABLE 6

Peak Storage[a/] and Number of Warehouses[b/] Required for Seed Cotton Bales, by Model Ginning Plant and Length of Season
San Joaquin Valley, California, 1971

Plant capacity	Length of season					
	6 months		9 months		11 months	
	Peak storage	Warehouses required	Peak storage	Warehouses required	Peak storage	Warehouses required
bales per hour	bales		bales		bales	
7½	7,950	2	13,810	4	17,738	5
15	15,900	4	27,620	7	35,476	9
22½	23,850	6	41,430	11	53,214	14
30	31,800	8	55,240	14	70,952	18
37½	39,750	10	69,050	18	88,690	23
45	47,700	12	82,860	21	106,428	27
60	63,600	16	110,480	28	141,904	36
75	79,500	20	138,100	35	177,380	45
90	95,400	24	165,720	42	212,856	54

a/ Figures are in lint bales, equivalent to 1,500 pounds of seed cotton.

b/ Warehouses are 140 feet wide by 250 feet long with 16-foot sidewalls. Capacity is equivalent to 4,000 bales of lint when used for storing seed cotton baled with a hay baler.

Source: Calculated.

was tested by Kirk, Bilbro, and Ray and was found to be capable of producing lint qualities closely comparable to those obtained from a commercial gin.[1] The purchase price for a gin of this size was obtained from a firm making laboratory–size ginning equipment.

Total investment costs for the receiving equipment discussed above are shown in Table 7. The only equipment presently available is made in units large enough to handle all volumes studied here. Therefore, all gin models have the same set of equipment and the same investment cost for receiving equipment.

Storage.––For the purposes of this study, it was specified that cotton be stored in warehouses. There are several justifications for this specification that essentially preclude the possibility of storing seed cotton without warehouses for the long storage periods considered in the study. Cotton insurance companies charge lower insurance rates for cotton under cover than they do for cotton left out in the open. Warehouse storage of seed cotton enables the ginner to precondition cotton to the proper moisture level prior to ginning. This speeds up the ginning process and could reduce the need for driers. Another reason for inside storage is the fear of potentially adverse weather conditions. Rain, fog, and excessive heat would adversely affect the moisture content of seed cotton stored outside. Construction of warehouses at the gin plant site would also allow space for lint cotton storage eliminating the need to haul lint cotton bales to warehousing facilities at other locations.

Seed cotton requires essentially the same type of storage facilities as lint cotton. An optimum–size warehouse was not calculated in this study due to the many unknowns involved with the storage of seed cotton. However, the concensus among lint cotton warehouse personnel and warehouse builders was that the 140′ x 250′ warehouse is the most desirable for cotton storage. This size is presently being used at several locations for lint cotton storage.

The capacity of a 140′ x 250′ warehouse was calculated using the 150–pound bale as discussed previously. Allowing for insurance company requirements, each warehouse can store 38,100 seed cotton bales or 3,810 lint–equivalent bales. The total storage capacity per warehouse was rounded to 4,000 lint–equivalent bales.

The number of warehouses required per gin facility is a function of the maximum volume of seed cotton in storage at any one time. Using the peak storage requirements in Table 6, it was possible to compute the number of warehouses required per facility by ginning rate and seasonal length. Table 6 shows that the number of warehouses required varied between 2 for the 7½–bale–per–hour, 6–month model, and 54 for the 90–bale–per–hour, 11–month model.

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[1] U. S. Agricultural Research Service, *Evaluation of Laboratory Gin for Processing, Hand–Snapped and Machine–Stripped Cotton,* by I. W. Kirk, J. D. Bilbro, Jr., and L. L. Ray, ARS 42-85 (1963), 6p.

TABLE 7

Estimated Capital Requirements for Seed Cotton Receiving and Storage Facilities
by Major Capital Components, Length of Season, and Plant Capacity
San Joaquin Valley, California, 1971

Capital components a/	Plant capacity (bales per hour)								
	7½	15	22½	30	37½	45	60	75	90
	dollars								
6 months									
Land	4,000	8,000	12,000	16,000	20,000	24,000	32,000	40,000	48,000
Grading; paving	21,000	42,000	56,700	75,600	94,500	113,400	151,200	189,000	226,800
Foundation	10,500	21,000	28,350	37,800	47,250	56,700	75,600	94,500	113,400
Warehouses	93,992	187,984	253,782	338,376	422,970	507,564	676,752	845,940	1,015,128
Sprinkler system	27,766	55,532	74,970	99,960	124,950	149,940	199,920	249,900	299,880
Humidifiers	6,666	13,332	18,000	24,000	30,000	36,000	48,000	60,000	72,000
Water tower	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Sample gin	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
Moisture meter	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400
Taxes	12,166	20,362	26,160	33,557	40,954	48,350	63,144	77,937	92,730
Total	255,490	427,610	549,362	704,693	860,024	1,015,354	1,326,016	1,636,677	1,947,338
9 months									
Land	8,000	14,000	22,000	28,000	36,000	42,000	56,000	70,000	84,000
Grading; paving	42,000	66,150	103,950	132,300	170,100	198,450	264,600	330,750	396,900
Foundation	21,000	33,075	51,975	66,150	85,050	99,225	132,300	165,375	198,450
Warehouses	187,984	296,079	465,267	592,158	761,346	888,237	1,184,316	1,480,395	1,776,474
Sprinkler system	55,532	87,465	137,445	174,930	224,910	262,395	349,860	437,325	524,790
Humidifiers	13,332	21,000	33,000	42,000	54,000	63,000	84,000	105,000	126,000
Water tower	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Sample gin	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
Moisture meter	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400
Taxes	20,362	29,858	44,652	55,747	70,540	81,635	107,524	133,412	159,300
Total	427,610	627,027	937,689	1,170,685	1,481,346	1,714,342	2,258,000	2,801,657	3,345,314
11 months									
Land	10,000	18,000	28,000	36,000	46,000	54,000	72,000	90,000	108,000
Grading; paving	52,500	85,050	132,300	170,100	217,350	255,150	340,200	425,250	510,300
Foundation	26,250	42,525	66,150	85,050	108,675	127,575	170,100	212,625	255,150
Warehouses	234,980	380,673	592,158	761,346	972,831	1,142,019	1,522,692	1,903,365	2,284,038
Sprinkler system	69,415	112,455	174,930	224,910	287,385	337,365	449,820	562,275	674,730
Humidifiers	16,665	27,000	42,000	54,000	69,000	81,000	108,000	135,000	162,000
Water tower	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Sample gin	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
Moisture meter	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400
Taxes	24,460	37,255	55,747	70,540	89,032	103,825	137,110	170,396	203,681
Total	513,670	782,358	1,170,685	1,481,346	1,869,673	2,180,334	2,879,322	3,578,311	4,277,299

a/ Investment costs are based on plant capacities contained in Table 4.

Source: Calculated.

All warehouses are equipped with sprinklers and humidifiers. Sprinklers are required by cotton insurance companies for warehouse storage. Humidifiers are required for lint cotton storage and are also needed if seed cotton is to be properly conditioned prior to ginning. The humidifiers would thus allow warehouses to be used for storage of either type of cotton.

Total land requirements for both receiving and storage facilities were figured on the basis of land required per warehouse. In addition to the land required for the warehouse itself, 100 feet of clearance was also required between warehouses, an insurance company requirement. The spacing also allows adequate room for maneuverability and accessability for incoming trucks in the receiving operation. Total land required per warehouse was estimated to be two acres. An estimate of $1,000 per acre was obtained from interviews with gin managers in the Valley. The cost of grading and paving the land was obtained from a construction company.

Cotton lint warehouses are presently advised by insurance companies to have a water tower with sufficient capacity to act as a reserve water supply for a fire restricted to one warehouse. The water tower in general use for the size warehouse used here has a capacity of 100,000 gallons.

Total Investment.––Total investment costs for receiving and storage facilities are shown in Table 7 by gin size and length of season. Warehouse requirements, as estimated previously (Table 6), were used to determine the equipment required per facility. A 10 percent discount which applies to warehouses, foundations, sprinklers, humidifiers, and grading and paving costs is ordinarily given if over five warehouses are constructed. This discount is included in the cost figures where appropriate. Construction, freight, and installation charges are also included. Total investment costs ranged from $225,490 with the 7½–bale–per–hour facility operating for 6 months to $4,277,299 for a 90–bale–per–hour facility operating for 11 months. For each of the model receiving and storage facilities, warehouses were the single highest investment item, equaling about 50 percent of the total investment in most cases.

Annual Costs of Investment

The investment costs, as given above, form the basis for determining annual fixed costs for the receiving and storage facilities. These costs include property taxes, depreciation allowances, interest on investment, insurance, and repair and maintenance costs. Two U. S. Department of Agriculture studies on lint cotton storage costs supplemented the data collected from industry personnel in determining fixed costs.[1]

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[1] U. S. Economic Research Service, *Storing and Handling Cotton in Public Facilities––An Evaluation of Cost Structures in 1964–65 and 1969–70,* by Joseph L. Ghetti *et al.,* ERS–469 (1971), 72p.

Idem, Cost of Storing and Handling Cotton at Public Storage Facilities, 1969–70, with Projections for 1971–72, by Joseph L. Ghetti and Whitman M. Chandler, Jr., ERS–472 (1971), 37p.

For the purpose of this study, a rate of 1–3/4 percent of capital investment was used as an average property tax rate. Depreciation costs, the largest fixed cost component, depend on the expected use life of the item. The straight–line depreciation method was used.[1] The annual cost of interest on investment was estimated at 6–1/2 percent. This rate was applied to an average undepreciated investment equal to one–half of the total investment. Interest was charged to the full value of land. Fixed insurance charges include fire and comprehensive insurance on all buildings and equipment. Cotton insurance is discussed later. An annual cost of 1 percent of the total cost of investment, excluding land, was estimated for insurance costs. A rate of 2 percent of capital investment, excluding land, was used as an estimate of annual costs for repairs and maintenance. Due to the nature of the warehousing function, it was not necessary to calculate a separate cost for repairs as a function of volume. Therefore, all repair and maintenance costs are included within this fixed cost component.

Total annual costs (fixed costs) associated with investment are shown in Table 8. Total annual fixed cost for the receiving and storage facilities ranges from $29,778 for the lowest volume model to $490,653 for the highest volume model.

Variable Costs of Operation

Costs of receiving and storage operations that vary with the volume handled include labor, equipment rental, sampling costs, seed cotton insurance, lint cotton storage costs, and miscellaneous costs.

Labor.––Labor requirements for seed cotton receiving and storage operations are a function of the daily seed cotton flow rate during each shift of the receiving and storage seasons. Thus, only changes in gin plant capacity affect labor requirements between gin models; seasonal length does not affect labor requirements. While these seed cotton flows may not always coincide with actual flows, it is probably not practical for management to attempt to alter the size of the labor force to meet daily fluctuations in cotton receipts.

The labor requirements could not be directly estimated from accounting data or time studies since the operations described in this study are not presently in use. However, it was possible to derive realistic estimates from labor requirements for the handling of baled lint cotton.[2]

The volume that can be unloaded per shift by one man operating a 3,000–pound lift truck equipped with clamps was estimated to be 4,800 seed cotton bales.[3] A man

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[1] For a listing of depreciation schedules and costs, see Appendix Table 1, *infra*, p. 81.

[2] Charles Martin, Agricultural Research Service, U. S. Department of Agriculture, Bakersfield, California, assisted in the cost estimation.

[3] This function included unloading bales from incoming trucks at the ground level and stacking in temporary blocks next to the trucks in front of the warehouse. The estimate is based on the ability of a 3,000–pound clamp truck to handle 16 seed cotton bales in one load.

TABLE 8

Annual Fixed and Variable Costs for Seed Cotton Receiving and Storage Facilities for 6-, 9-, and 11-Month Ginning Seasons by Major Cost Item and Ginning Capacity, San Joaquin Valley, California, 1971

Length of season; bales per hour[a/]	Total fixed costs	Variable costs: Labor[b/]	Variable costs: Equipment rental[c/]	Variable costs: Seed cotton insurance[d/]	Variable costs: Sampling[e/]	Variable costs: Miscellaneous[f/]	Variable costs: Lint cotton storage[g/]	Variable costs: Total	Total fixed and variable costs	Fixed cost per bale[h/]	Variable cost per bale[h/]	Total cost per bale[h/]	Seasonal volume
	dollars												bales
6 months													
7½	29,778	19,322	3,684	3,179	1,988	922	5,808	34,903	64,681	2.38	2.79	5.17	12,528
15	49,517	21,170	4,319	6,359	3,975	1,844	11,616	49,283	98,800	1.98	1.97	3.95	25,056
22½	63,439	23,298	5,287	9,504	5,963	2,767	17,424	64,243	127,682	1.70	1.72	3.42	37,388
30	81,240	32,454	8,594	12,684	7,950	3,689	23,232	88,603	169,843	1.63	1.78	3.41	49,916
37½	99,039	35,086	9,498	15,863	9,938	4,611	29,040	104,036	203,075	1.59	1.67	3.26	62,444
45	116,843	36,654	9,917	19,042	11,925	5,533	34,848	117,919	234,762	1.56	1.57	3.13	74,972
60	152,442	45,810	13,396	25,367	15,900	7,378	46,464	154,315	306,757	1.53	1.55	3.08	99,832
75	188,043	57,318	17,491	31,724	19,875	9,222	58,080	193,710	381,753	1.51	1.55	3.06	124,888
90	223,645	69,106	21,846	38,049	23,850	11,066	69,696	233,613	457,258	1.49	1.56	3.05	149,748
9 months													
7½	49,517	24,544	5,533	5,901	3,453	2,306	2,791	44,528	94,045	2.64	2.37	5.01	18,792
15	72,339	26,952	6,581	11,804	6,905	4,613	5,581	62,436	134,775	1.92	1.66	3.58	37,584
22½	107,942	29,864	7,659	17,654	10,358	6,919	8,372	80,826	188,768	1.92	1.44	3.36	56,082
30	134,643	44,242	12,490	23,555	13,810	9,225	11,163	114,485	249,128	1.80	1.53	3.33	74,874
37½	170,243	46,874	13,807	29,456	17,263	11,531	13,954	132,885	303,128	1.82	1.42	3.24	93,664
45	196,943	48,722	14,466	35,359	20,715	13,838	16,744	149,844	346,787	1.75	1.33	3.08	112,456
60	259,246	66,012	20,837	47,110	27,620	18,450	22,326	202,355	461,601	1.73	1.35	3.08	149,746
75	321,548	83,022	26,985	58,914	34,525	23,063	27,907	254,416	575,964	1.72	1.36	3.08	187,330
90	383,849	98,464	32,692	70,667	41,430	27,675	33,489	304,417	688,266	1.71	1.36	3.07	224,620
11 months													
7½	59,386	27,260	6,637	8,090	4,435	3,530	0	49,952	109,338	2.59	2.17	4.76	22,968
15	90,139	32,020	8,373	16,182	8,937	7,060	0	72,572	162,711	1.96	1.58	3.54	45,936
22½	134,643	34,148	9,205	24,211	13,304	10,590	0	91,458	226,101	1.96	1.33	3.29	68,546
30	170,243	52,586	15,587	32,303	17,738	14,119	0	132,333	302,576	1.86	1.45	3.31	91,514
37½	214,744	55,162	16,664	40,393	22,173	17,649	0	152,041	366,785	1.88	1.33	3.21	114,482
45	250,345	58,354	18,060	48,483	26,607	21,179	0	172,683	423,028	1.82	1.26	3.08	137,450
60	330,448	79,368	25,591	64,603	35,476	28,239	0	233,277	563,725	1.81	1.27	3.08	183,028
75	410,550	99,094	33,882	80,786	44,345	35,299	0	293,406	703,956	1.79	1.28	3.07	228,966
90	490,653	119,100	40,400	96,906	53,214	42,358	0	351,978	842,631	1.79	1.28	3.07	274,544

a/ Manufacturer's rating of the gin associated with each receiving and storage facility.
b/ Includes labor for receiving, sample ginning, moisture testing, storing, and break-out.
c/ Includes equipment fuel and equipment for receiving, storing, and break-out.
d/ Includes insurance on seed cotton during assembly, receiving, and storage.
e/ 25 cents per lint-equivalent bale on seed cotton to be stored.
f/ Includes sample wrappers, utilities, supplies, licenses, and other miscellaneous costs.
g/ 17 cents per bale-month.
h/ Lint-equivalent bale.

Source: Calculated.

operating the same size lift truck could place 2,880 seed cotton bales in storage during an eight–hour shift.[1] These estimates include allowance for normal delays and rest periods. Table 9 utilizes the labor estimates above and the seasonal flows in Table 5 to show the labor required per shift for receiving and storage operations for all gin models for the 11–month ginning season. Estimates for the 6– and 9–month seasons were devised in a similar manner. The labor required during the peak period is employed for an additional two weeks during both shifts to allow for flexibility in receiving capacity. Also, it probably would be necessary to guarantee seasonal labor employment for at least four weeks. Thus, during the two weeks directly following the peak period, there will be some excess labor capacity. In all cases the labor required was rounded to the next highest whole number.

A labor force of clamp truck drivers also must be hired to break bales out of storage and deliver them to the gin door. (During the receiving season, the break–out crew also delivers bales from the receiving areas to the gin door.) The time required to pick up and transport a truckload of baled seed cotton from warehouse to gin door depends on the distance to be traveled and the time spent locating the desired bales. The following formula was developed using previously established relationships for lint cotton handling:[2]

$$A = \frac{B\ (1{,}040 + D)}{2{,}560{,}000}$$

where

A = men per shift

B = cotton ginned per shift in seed cotton bales

and

D = average one–way travel distance from warehouse to gin (for distances over 400 feet).[3]

Using this formula, the following number of men are required for the break–out crew for each gin model:

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[1] This function included transporting bales from temporary blocks in front of the warehouse and stacking in 15–foot–high stacks inside the warehouse.

[2] Derived from cotton–handling relationships supplied by Martin, *op. cit.*

[3] The distance (D) used in the study varied depending upon the number of warehouses required and the locational pattern assumed.

TABLE 9

Labor Requirements for Receiving and Storage Operations During Specified Two-Week Periods for Model Ginning Plants, by Length of Season[a/]
San Joaquin Valley, California, 1971

Plant capacity and operations		October 1; 1 percent	October 18; 15 percent	November 1; 39 percent	November 14; 27 percent	December 1; 12 percent	December 13; 4 percent	January 1; 2 percent
		End of two-week period and percentage processed per period[b/]						
		man equivalents per shift						
7½-bale-per-hour plant:	Receiving[c/]	.05	.26	.67	.46	.58	.19	.10
	Storage[c/]	.08	.31	.99	.65	.62	0	0
	Total[c/]	.13	.57	1.66	1.11	1.20	.19	.10
	Men/day shift	d/	1	2	2	2	d/	d/
	Men/night shift	0	1	2	2	0	0	0
15-bale-per-hour plant:	Men/day shift	1	2	4	4	3	1	d/
	Men/night shift	0	2	4	4	0	0	0
22½-bale-per-hour plant:	Men/day shift	1	2	5	5	4	1	1
	Men/night shift	0	2	5	5	0	0	0
30-bale-per-hour plant:	Men/day shift	1	3	7	7	5	1	1
	Men/night shift	0	3	7	7	0	0	0
37½-bale-per-hour plant:	Men/day shift	1	3	9	9	6	1	1
	Men/night shift	0	3	9	9	0	0	0
45-bale-per-hour plant:	Men/day shift	1	4	10	10	8	2	1
	Men/night shift	0	4	10	10	0	0	0
60-bale-per-hour plant:	Men/day shift	1	5	14	14	10	2	1
	Men/night shift	0	5	14	14	0	0	0
75-bale-per-hour plant:	Men/day shift	2	6	17	17	12	2	1
	Men/night shift	0	6	17	17	0	0	0
90-bale-per-hour plant:	Men/day shift	2	7	20	20	15	3	1
	Men/night shift	0	7	20	20	0	0	0

a/ Labor for moisture testing, sampling, sample ginning, and break-out crews is not included here.

b/ Based on an average for ginnings in the San Joaquin Valley for 1969, 1970, and 1971.

c/ Equivalent data for 15-, 22½-, 30-, 37½-, 45-, 60-, 75-, and 90-bale-per-hour gins can be computed by multiplying by 2, 3, 4, 5, 6, 8, 10, and 12, respectively.

d/ If less than .20 man equivalents are required, it was assumed that no men would be needed. Men working on the break-out crew could easily perform the duties required.

Source: Calculated.

Bales per hour	*Men per shift*
7½	1
15	1
22½	1
30	2
37½	2
45	2
60	3
75	4
90	5

Break–out crews were hired for the same number of hours as the gin crew.

The operation of the sample gin also requires a labor crew. Three men are needed in the peak season, October 1–November 14, while only two men are needed from September 15–October 1 and November 15–December 1. After December 1, the storing season is over and there is no need to operate a sample gin. One man is also required to operate the moisture meter during each shift of the receiving period.

Hourly labor costs are based on hourly wage rates plus any fringe benefits received. The hourly cost of hiring each type of employee including fringe benefits is listed below. These costs were estimated from data collected in interviews with cotton warehousemen and gin managers.

Job title	*Hourly labor cost*
Clamp truck drivers	$3.50
Head sample ginner	$3.00
Assistant sample ginners	$2.60
Moisture meter operator	$3.00

Total labor costs for receiving, sample ginning, moisture testing, storing, and break–out are shown in Table 8 by gin size and seasonal length. These costs ranged from $19,322 for the lowest volume facility to $119,100 for the highest volume facility.

Equipment.––The clamp trucks necessary for the receiving, storing, and breakout operations are considered to be leased. Therefore, the entire cost of operating the trucks is considered as a variable cost. The cost data were obtained from rates used by truck leasing companies and were obtained as $400 per month per 3,000–pound clamp truck. The cost of butane fuel was estimated to be 20 cents per hour. One clamp truck is leased for every clamp truck driver hired during the receiving, storing, and break–out seasons (Table 9).

Sampling.––The cost associated with the seed cotton sampling process was derived from previous studies by Campbell.[1] Campbell's estimate, as used in this study, was 25 cents per lint–equivalent bale for all services associated with seed cotton sampling up to but not including the sample ginning stage. This cost was applied only to seed cotton that required storage. No cost is assumed for the classing of the samples since this would be done at government classing stations. Table 8 contains a listing of total sampling costs.

Seed Cotton Insurance.––Fire insurance for seed cotton can be broken into two cost segments––before–storage insurance and in–storage insurance. The before–storage segment includes fire insurance from the time the seed cotton is in the pickers to the time it enters the storage warehouse. This cost was derived from existing rates used for loose seed cotton. The actual rate used was 12 cents per $100 of value. With a lint cotton value of 24 cents per pound and a seed price of $60 per ton, this amounted to 17 cents per lint–equivalent bale.

In–storage insurance costs were estimated from rates now applied to the storage of baled lint cotton in warehouses. Insurance company representatives stated that the cost of storage insurance for baled seed cotton would be higher than the cost for baled lint cotton storage. This was due primarily to the lack of knowledge concerning seed cotton storage. An estimate of 36 cents per $100 of value annually was chosen as an approximate cost. This rate will not vary with volume stored, but the total cost per bale will change depending on the length of time the bale is in storage. The average storage period for seed cotton, using the previous assumptions concerning seasonal flows, would be 5.9, 4.9, and 3.3 months for the 11–, 9–, and 6–month seasons, respectively. Thus, using the lint and seed values above, the cost of insurance for stored seed cotton would be 23.6 cents, 19.6 cents, and 13.2 cents per lint–equivalent bale for the 11–, 9–, and 6–month seasons, respectively. This rate was applied only to seed cotton actually stored.

In Table 8 seed cotton insurance costs are totaled for all facilities studied.

Lint Cotton Storage.––If the lint cotton is not sold by the time the ginning process is completed, it must be stored until scheduled for delivery. Storage facilities used for seed cotton before ginning would be used for lint cotton storage after ginning. There would be ample storage space available since lint cotton takes up less space than an equivalent quantity of seed cotton. It is expected that cotton would be sold at a constant rate during an 11–month selling season.[2] This assumption is realistic since mills presently

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[1] U. S. Farmer Cooperative Service, *Central Cotton Ginning, Comparative Costs . . .*; see, also, *idem,* "A Proposed System for Ginning. . . ."

[2] Here it is specified that all warehouses would be cleared by September 1 in preparation for the new ginning season beginning October 1. This allows a storage season of 11 months.

utilize cotton fiber at a near constant rate throughout the year and would rather not store cotton purchases any longer than necessary. Based on the previous assumptions, only gins operating for 6– or 9–month periods would store lint cotton; a gin in operation for 11 months would ship all cotton as it was ginned.[1]

The cost of storing lint cotton was considered only in terms of the variable cost component. All fixed costs associated with warehouse ownership have been allocated to seed cotton storage. Estimates were derived from a recent study of lint cotton warehousing costs in the West.[2] The cost of storage included (1) moving bales into designated storage areas, (2) stacking bales into tiers, (3) recording the location, and (4) performing other custodial functions during the storage period.

Variable costs associated with lint cotton storage were estimated as 17 cents per bale month including lint cotton insurance costs. Lint storage periods averaged 6 and 4.8 months for the 6– and 9–month seasons, respectively. These storage periods were used in combination with the estimated variable cost storage rate to determine the cost of storing lint cotton bales. The cost was applied only to those bales that were not shipped immediately following ginning (Table 8).

Miscellaneous.—–Costs for receiving and storage operations that were not included within other categories were included in miscellaneous costs. These costs included sample wrappers, utilities, warehouse supplies, office supplies for the warehouse operation, licenses, and other miscellaneous items. Miscellaneous costs were obtained from an Economic Research Service study of cotton storage costs.[3] A cost of 19.9 cents, 16.7 cents, and 11.6 cents per lint–equivalent bale was computed for the 11–, 9–, and 6–month ginning seasons, respectively. Costs were calculated only for seed cotton stored. Miscellaneous costs are totaled in Table 8.

Total Variable Cost.—–Total variable cost of storage was estimated as $34,903 for the lowest volume facility and $351,978 for the highest volume facility studied (Table 8). In the 9– and 11–month season models, labor was the largest variable cost item; seed cotton insurance was the second largest. Labor and lint cotton storage were the first– and second–highest variable cost items, respectively, in the single–battery plants that operated for six months, but labor cost was second to lint cotton storage cost in the double–battery models operating for six months.

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[1] It is recognized that, in an actual situation, some amount of lint cotton would have to be stored during an 11–month season, either because it had not been sold or because it was not scheduled for delivery immediately after ginning.

[2] U. S. Economic Research Service, *Cost of Storing and Handling Cotton. . . .*

[3] *Ibid.*

Total Annual Fixed and Variable Costs

The previous fixed and variable cost items are summed in Table 8 to obtain the total annual costs for operating a receiving and storage facility for each gin size and length of operating period. For the facility serving a 7½–bale–per–hour plant and operating for a 6–month season, total cost was $64,681. The facility serving the 90–bale–per–hour, 11–month plant, incurred an annual operating cost of $842,631.

These costs demonstrated economies of scale, as model gin size increased, for receiving and storage facilities operating for all seasonal lengths. Both more efficient utilization of investment and more efficient use of labor and rental equipment helped account for the reduced cost per bale as model gin size increased. Average total cost (11–month season) for lint–equivalent bales ranged between $4.76 per bale for the smallest facility to $3.07 per bale for the largest facility.[1] For all three seasons, average costs declined at a slower rate for facilities larger than those serving the 22½–bale–per–hour plant. Thus, for all seasons studied, most of the economies of scale were exhausted with the 7½, 15–, and 22½–bale–per–hour models.

Long–Run Total Receiving and Storage Costs

A long–run average cost curve or planning curve was derived statistically for each seasonal length. These curves were formed by first using a least–squares regression analysis to fit a linear function to the nine points representing the total operating cost for each receiving and storage facility. The following total long–run cost curves were derived:

$$TSC_1 = 25{,}064 + 2.856656x$$

$$TSC_2 = 29{,}107 + 2.911062x$$

$$TSC_3 = 30{,}561 + 2.934470x$$

where

TSC_1 = long–run total receiving and storage cost for a 6–month ginning season

TSC_2 = long–run total receiving and storage cost for a 9–month ginning season

[1] Average costs are based on the assumption that the specified seasonal volumes are actually processed.

TSC_3 = long–run total receiving and storage cost for an 11–month ginning season

and

x = total seasonal volume.

The three equations represent the relationship between annual operating costs and total annual volume received when the scale of the facility is allowed to vary for each of the three operating seasons specified.

The coefficient of determination, r^2, for each of the above equations was .99. The r^2 statistic can best be interpreted as a measure of the goodness of fit of the estimated regression equations and the synthesized cost points. Since the synthesized cost points do not satisfy the stochastic assumption of least–squares regression, the r^2 statistic cannot be interpreted in the sense of percentage of variation in the dependent variable associated with variation in the independent variable.

In a later section the long–run total ginning cost functions are added to the functions derived above to obtain the long–run total cost functions for receiving, storing, and ginning.

GINNING

The Ginning Process

The processes used in the ginning of cotton consist of a number of separate but related operations.[1] Figure 7 outlines the flow of cotton as it moves through the ginning process. The following discussion describes the processes involved.

Tie Removal and Blending.——Seed cotton is removed from warehouses and transported to the gin in baled form as described in the previous section. The ties holding the bale are removed and the loose cotton dumped into blending bins. Blending techniques are currently being developed in the Texas High Plains and will be in use at a large–capacity gin beginning with the 1973–74 season. The blending process would most likely include only the blending of like grades and qualities of cotton. This procedure would be carried out before the beginning of normal gin processing. Its principal benefit would be to help assure the mills a more uniform product and possibly assure the grower a higher price.

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[1] The engineering and technical aspects of the ginning process are described in U. S. Agricultural Research Service, *Handbook for Cotton Ginners,* Agricultural Handbook No. 260 (1964).

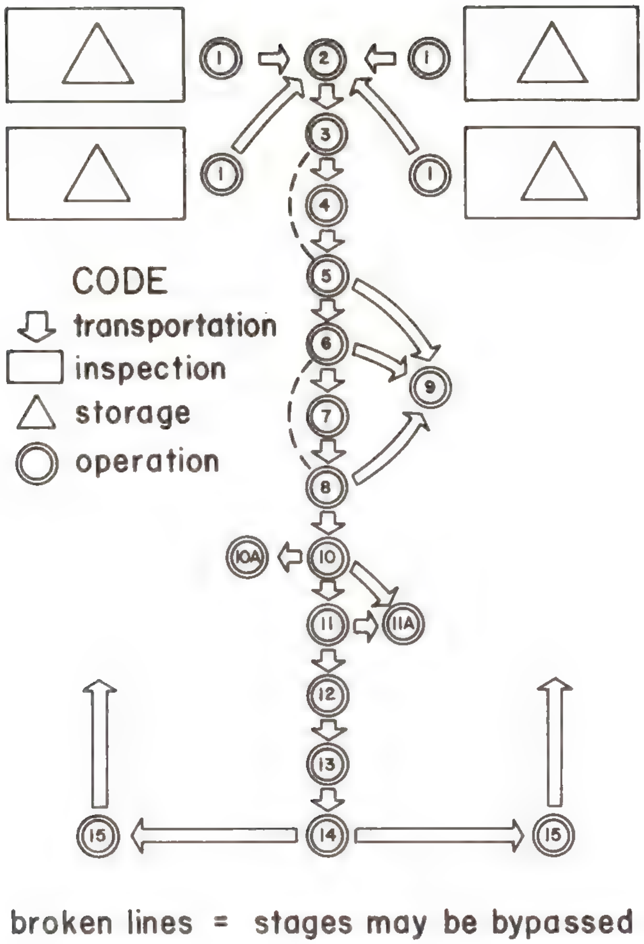

FIGURE 7. Central Ginning Operations

1. Removal of seed cotton from storage in desired quantities and qualities
2. Remove ties; blend
3. Feed control
4. First–stage drying
5. First–stage cleaning
6. Stick machine
7. Second–stage drying
8. Second–stage cleaning
9. Trash collection
10. Feeder and gin stands
10a. Cottonseed collection
11. Lint cleaners
11a. Motes and waste lint collection
12. Automatic sample machine
13. Tramper and press
14. Bale weighing
15. Transfer baled lint to warehouse or directly to rail cars

Drying, Cleaning, and Ginning.——Following the blending and introduction of the seed cotton into the gin building, the cotton begins a continuous flow through the plant to the bale press stage with various "branch offs" along the way.

An automatic feeder controls the flow of the seed cotton as it enters the first stage to the cleaning and drying equipment. Foreign matter is removed by air to the outside trash collection center. Second–stage drying or cleaning equipment also is usually available but can be bypassed if not required.

After the seed cotton is properly conditioned for ginning, it flows to the feeder unit above the gin stands. The number, size, and efficiency of these stands are the major determinants of gin capacity. All other equipment must be geared to process at the same rate as the stands.

Seed and small particles of trash are separated from the lint fibers in the gin stand and diverted to the cottonseed and trash collection centers outside the gin building. Trash is hauled away or burned in an incinerator on the plant grounds. Seed is a valuable by–product of cotton and is shipped to cottonseed crushing and oil mill facilities.

The cotton moves next through the lint cleaners. These machines remove most of the remaining trash particles including the cotton motes. From the lint cleaners, the lint flows into the bale pressbox where it is compressed into a bale weighing approximately 500 pounds. The bale is then tagged and weighed.

The gin models studied here utilize a universal density gin press, making a bale of approximately 28 pounds per cubic foot. A bale of this density does not have to be recompressed to a higher density at the warehouse before shipment to the mills.

Two methods currently exist for performing the lint sampling operation. In many gins the sample is taken after the cotton is baled by using a knife to cut a small section from each bale. However, this method is inefficient, both in terms of man hours and fiber waste. Further, it does not provide a good random sample.[1] The alternative technique also is in widespread use; a sample of the lint is taken before it enters the bale press. This is done through the use of an automatic sampling machine that extracts random samples as the cotton lint moves from the lint cleaning stage to the packaging stage. The finished bale is left as a neat, clean package; and the cotton buyer is assured a more representative sample.

The finished bale is normally moved to a waiting truck or is temporarily stored in the gin yard until it is picked up for delivery to the warehouse compress. However, under the framework of the central ginning system discussed here, the finished bale would be either loaded on a freight car at the gin and shipped to the mill or moved to temporary storage in a warehouse on the gin site.[2]

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[1] National Cotton Council of America, "Possibilities for Improving Efficiency in Certain Aspects of Raw Cotton Handling and Marketing" (Memphis, Tennessee, 1966), p. 3.

[2] Bales to be sold on the export market would be transported by truck to the nearest port.

Previous Research

In synthesizing the costs for each of the gin models, previous cost–of–ginning studies were used extensively. This was feasible because of the wealth of literature concerning cotton ginning costs, some of very recent origin. It was necessary to adapt much of the cost information used to reflect differences in price levels and location of facilities. The studies of most direct benefit in determining ginning costs for this project were done by Covey and Hudson; Campbell; Looney and Wilmot; and Cable.[1]

Investment Costs for Model Ginning Plants

In this study nine gin models are considered, three of which consist of dual processing lines. The sizes in terms of the manufacturer's rating are 7½, 15, 22½, 30, 37½, 45, 60, 75, and 90 bales per hour. The models specified are all in multiples of 7½ bales per hour, the size gin stand typical of those being installed in modern high–capacity gins. Since the gin stand represents the main bottleneck in the ginning process, all other equipment is designed to match the capacity of the stand.

In previous studies a productive capacity of 85 percent of the manufacturer's rating has been used for calculating the actual volume attainable by each model plant. The productive capacity is that volume actually attainable by the plant after making allowance for temporary delays due to nonoptimal ginning conditions and to repairs and maintenance. Annual volume based on productive capacity is listed in Table 4 for each gin model.

Costs for the model plants are based on operation for two 8–hour shifts per day, five days per week. Plants operate for 6, 9, and 11 months per year depending on the season specified. Using these assumptions, the annual volume of these gin models ranged between 12,528 and 274,544 bales (Table 4).

Building and equipment specifications and costs for the model plants in this study were derived from information supplied by a major gin equipment manufacturer as well as from previous ginning cost studies. Since all cotton in the San Joaquin Valley is machine–picked, the equipment specified was for this harvest method.

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[1] Covey and Hudson, *op. cit.*

U. S. Farmer Cooperative Service, *Central Cotton Ginning, Comparative Costs. . . .*

U. S. Economic Research Service, *Economic Models. . . .*

Cecil Curtis Cable, Jr., "Economic Models for a Cotton Ginning–Warehousing Complex" (unpublished Ph.D. dissertation, University of Minnesota, St. Paul, 1967).

The gin machinery manufacturer was able to supply cost estimates for building and equipping gin plants up to and including a 45–bale–per–hour gin. This size is approximately the manufacturer's rating of the highest capacity gin plant now in existence. However, even this size gin might not allow for all possible economies of scale through even higher capacity gins. Present–day equipment available from the machinery companies was not adequate for attaining an hourly output greater than 45 bales with one processing line. Based on interviews with gin managers and gin equipment company personnel, it was determined that a dual processing line (within a separate building) was a more appropriate method for obtaining capacities greater than 45 bales per hour. The 60–, 75–, and 90–bale–per–hour gins are plants having dual processing lines with each line limited to a capacity of one–half the total plant capacity.

All costs for dual–line (double–battery) plants were estimated from the single–line plants, but various cost savings available in building two–battery plants were recognized. In addition, it was especially helpful to observe cost structures in existing two–battery ginning plants. The cost of supplying most of the minor capital items would not double when an additional gin battery (of capacity equal to the original) was built at the original site. These items included land, office and scale facilities, pavement, tools, rail siding, motor vehicles, fire protection, and construction labor. However, the cost of major items such as gin buildings and machinery would be expected to double when building an additional battery.

Investment requirements for the nine gin plant models were estimated to range from $473,900 for the smallest to $2,349,600 for the largest. Table 10 contains a listing of the investment requirement for each capital item required by each gin model. The largest investment item, gin machinery, accounted for 67–77 percent of total investment in each gin model.

Annual Costs of Investment

Annual fixed costs include property taxes, depreciation allowances, interest on investment, insurance, and management costs.

The property tax rate used for the ginning cost function was 1.75 percent of capital investment, the same as that used for storage costs. Annual depreciation rates using the straight–line depreciation method varied for different capital items. These rates are listed along with annual depreciation costs in Appendix Table 2. Annual interest cost was computed at 6½ percent of one–half the total investment cost of all items except land. Since land does not depreciate in value, interest for that item will average 6½ percent of full investment cost annually. The cost of fire and comprehensive insurance on all buildings and equipment is also considered an annual fixed cost. The insurance rate used here was 1 percent of investment excluding land.

TABLE 10

Estimated Capital Requirements for Model Ginning Plants for Processing Machine-Picked Cotton, by Major Physical Components and Plant Capacity[a/]
San Joaquin Valley, California, 1971

Capital components	Plant capacity (bales per hour)								
	7½	15	22½	30	37½	45	60	75	90
	1,000 dollars								
Land	12.0	16.0	19.0	25.0	30.0	35.0	40.0	45.0	50.0
Gin buildings[b/]	50.8	62.0	63.3	73.5	85.8	112.0	145.0	169.6	222.0
Gin machinery[c/]	315.5	457.0	573.6	726.0	810.9	899.0	1,447.0	1,615.8	1,788.0
Office, scale[d/]	22.2	23.0	23.9	24.8	25.7	26.5	27.3	28.1	28.9
Paving	37.8	50.0	62.5	75.0	87.5	100.0	107.5	115.0	125.0
Tools	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Rail siding[e/]	8.7	8.7	8.7	10.0	10.0	11.4	14.0	15.4	16.7
Car, truck	4.0	4.0	4.0	4.0	4.0	4.0	6.0	6.0	6.0
Sales tax[f/]	20.9	28.9	35.3	43.8	49.0	54.3	83.8	93.2	103.0
Total investment	473.9	652.6	794.3	987.1	1,108.9	1,249.2	1,878.6	2,097.1	2,349.6

a/ The 60-, 75-, and 90-bale-per-hour plants consist of two processing lines, each of half the total capacity. Costs are estimated for plants within the San Joaquin Valley. Storage facilities are not included.

b/ Includes installation, foundation, seed collection facilities, and fire protection equipment.

c/ Includes freight, installation, universal density press, automatic strapping machines for gins 30 bales per hour and over, seed cotton blending equipment, trash collection equipment, and all gin machinery.

d/ Includes office fixtures and equipment.

e/ Southern Pacific Railroad: track--$17 per foot; platform--75 cents per square foot.

f/ 5 percent California sales tax on all except land, construction labor, and freight.

Source: Calculated.

Salaries for management personnel were considered to be a fixed cost. Interviews with gin managers provided the basis for the salaries used in the study. Management was divided into four categories: plant manager, gin superintendent, head ginner, and bookkeeper. Salary for the plant manager would be slightly higher than in the normal ginning plant to compensate for the additional warehousing responsibilities required. All salaries are expected to increase with plant capacity since responsibilities increase with annual volumes. Management costs are detailed in Table 11.

Table 11 shows a listing by plant size of all the fixed cost items required for each model plant. The range is between $72,652 for the 7½–bale–per–hour plant to $354,169 for the 90–bale–per–hour plant. Charges for depreciation were the largest fixed cost item. Managerial salaries and interest costs nearly tied for the second highest component of fixed cost, while taxes were third, and insurance was fourth.

Variable Costs of Operation

Major variable cost items include labor, bagging and ties, electricity, and repairs.[1] Items of smaller importance are dryer fuel, gin and office supplies, travel, and other miscellaneous costs.

Plant Labor.––Gin labor requirements depend primarily upon gin size, the condition of the equipment, the availability of seed cotton, and the manager's capability. Increases in gin size do not result in proportionate increases in labor requirements; in fact, the ratio of labor to capacity decreases as gin size increases.[2] Seed cotton is continuously available during the ginning season specified due to the existence of stored seed cotton. This eliminates the idle labor problem so often encountered during slack in the harvesting period.

Data concerning labor requirements were derived from interviews with plant managers and from previous ginning cost studies, especially Looney and Wilmot.[3] Although the model sizes used in previous studies were not identical to those used here, it was possible to interpolate labor requirements from gin models of similar sizes. It was estimated for the purposes of this study that approximately the same labor would be required for receiving either baled seed cotton or loose cotton. Thus, the labor normally required for suction unloading would be used for tie removal and blending.

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[1] Cotton is not normally insured during the ginning process.

[2] U. S. Economic Research Service, *Economic Models . . .*, p. 15.

[3] *Ibid.*

TABLE 11

Estimated Total Annual Fixed Cost for Model Ginning Plants Equipped to Handle Machine-Picked Cotton, by Major Cost Items and Plant Capacity
San Joaquin Valley, California, 1971

Cost item	Plant capacity (bales per hour)								
	7½	15	22½	30	37½	45	60[a/]	75[a/]	90[a/]
	dollars								
Management[b/]									
Plant manager	8,000	11,000	13,000	15,000	17,000	19,000	23,000	26,000	30,000
Superintendent	[c/]		9,200	9,500	9,700	10,000	10,500	11,000	11,500
Head ginner	7,000	7,300	7,600	8,000	8,300	8,700	16,000[d/]	16,600[d/]	17,400[d/]
Bookkeeper[e/]			6,500	6,500	6,500	6,500	7,500	7,500	7,500
Depreciation[f/]	28,946	40,151	49,255	61,284	68,577	76,421	109,646	130,913	145,704
Interest[g/]	15,794	21,736	26,436	32,895	37,004	41,574	62,352	69,616	77,951
Insurance[h/]	4,619	6,366	7,753	9,621	10,787	12,142	18,386	20,521	22,996
Taxes[i/]	8,293	11,420	13,900	17,274	19,402	21,861	32,875	36,699	41,118
Total fixed costs	72,652	97,973	133,644	160,074	177,270	196,198	280,259	318,849	354,169

a/ Plants with two processing lines, each of half the total capacity.

b/ Fringe benefits included.

c/ Blanks indicate not applicable.

d/ One head ginner must be hired for each gin battery.

e/ Assistant manager.

f/ Appendix Table 2, *infra*, p. 82.

g/ 6-1/2 percent of average lifetime investment; 6-1/2 percent of full investment in land.

h/ 1 percent of capital investment exclusive of land.

i/ 1-3/4 percent of total capital investment including land.

Source: Calculated.

Three separate crews make up the entire labor force required for running a cotton gin––the yard and receiving crew, the conditioning and ginning crew, and the bale–packaging crew.[1] Crews are split into two 8–hour shifts each day and work a five–day week. Presently, during the peak ginning season, gin crews normally work in two 12–hour shifts for a seven–day week. If seed cotton storage facilities are available, however, ginning can proceed at an even daily rate, and gin crews could be expected to work normal eight–hour shifts for a five–day week. Two 8–hour shifts per day would allow greater utilization of fixed facilities and yet allow time for repairs and unexpected emergencies. Furthermore, there would be no need to hire crews for late night hours.

Job functions for men in the yard crew consist of breaking the bands on seed cotton bales, dumping seed cotton into blending bins, mote collection, and yard cleanup. The conditioning and ginning crew is responsible for observing and regulating the conditioning and ginning machinery to assure proper operation and to detect the need for repairs and other changes in the automatic processes. When repairs or maintenance are necessary, these men also perform those tasks. Job functions for the bale–packaging crew include operating the automatic sampler, dressing the press, operating the press, tying out the bales, and weighing and recording. Some of these duties are performed automatically in the larger ginning plants.

Plant labor requirements for conditioning and ginning and bale–packaging crews in two–battery gins were equal to twice the requirements for single–battery gins. However, labor for the yard and receiving crew was not expected to double in the two–battery plants. This is due principally to savings available with yard labor. The total men required to run a ginning plant varied between 5 for the smallest plant to 24 for the 90–bale–per–hour, two–battery plant (Table 12).

Wage rates for gin crew labor were obtained from plant managers in the San Joaquin Valley. Allowances were made for such necessary costs as workmen's compensation, social security, and other fringe benefits. The hourly cost for plant labor including fringe benefits was obtained as $2.75 for the head pressman and $2.60 for all other gin crew employees.[2] Total plant labor costs are shown in Table 13 for the 7½–bale–per–hour model plant. Plant labor costs for all other models are contained in Appendix Tables 3–10.

Office Help.––Office help is normally considered a separate cost from gin crew labor. Office help requirements as well as costs were estimated from personal interviews with ginning managers and from previous ginning studies. Requirements for double–battery gins had to be interpolated from labor requirements for smaller gins.

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[1] Labor required to transport seed cotton bales from warehouse to gin (break–out labor) is included in receiving and storage labor.

[2] Wage rates paid by some gin managers include a premium for night crews. However, the practice is not uniform throughout the Valley. Wage rates used for purposes of this study do not include a premium.

TABLE 12

Estimated Number of Employees Per Crew for Model Ginning Plants Equipped to Handle Machine-Picked Cotton, by Plant Capacity
San Joaquin Valley, California, 1971

Plant capacity	Ginning crew			Total
	Yard and receiving	Conditioning and ginning[a/]	Bale packaging	
Bales per hour	number of employees			
7½	2	1	2	5
15	3	1	4	8
22½	3	2	5	10
30	4	2	4[b/]	10
37½	4	3	4	11
45	5	3	5	13
60[c/]	7	4	8	19
75[c/]	7	6	8	21
90[c/]	8	6	10	24

a/ The head ginner is not included here since he is considered a full-time employee.

b/ Plants with a ginning capacity of 30 bales per hour and larger are equipped with automatic strapping machines and automatic presses using pre-formed bale covering.

c/ Plants with two processing lines, each with half the total capacity.

Source: Calculated.

TABLE 13

Estimated Annual Fixed and Variable Costs for a 7½-Bale-Per-Hour Model Ginning Plant[a]
Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season
San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	57,652	57,652	57,652
Supervision	15,000	15,000	15,000
Total	72,652	72,652	72,652
Variable costs			
Office help[c]	4,200	7,400	7,400
Plant labor	27,457	41,186	50,388
Electrical energy	8,989	13,483	16,480
Bagging and ties[d]	40,716	61,074	74,646
Repairs[e]	19,669	29,503	36,060
Miscellaneous[f]	21,172	31,758	38,816
Total	122,203	184,404	223,740
Total fixed and variable costs	194,855	257,056	296,392
Fixed cost per bale	5.80	3.87	3.16
Variable cost per bale	9.75	9.81	9.74
Total cost per bale	15.55	13.68	12.90
Seasonal volume (bales)	12,528	18,792	22,968

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per day.

c/ Two employees, one 8 hours per day and one 4 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $3.25 per bale for jute.

e/ $1.57 per bale.

f/ $1.69 per bale. This includes fuel for drivers, gin and office supplies, other utilities, advertising, telephone, travel, dues, meetings, rentals, and auto and truck operating expenses.

Source: Calculated.

In all models, plants ginning for 6 months would hire office help for 7 months, while those operating for 9 and 11 months would hire office employees for the entire year.

The cost of office labor was estimated to be $2.30 per hour including social security and disability benefits. A bonus, often added by gin managers for full–time workers, is included at $200 per year for employees working 12 months (see Table 13 for office help costs for the 7½–bale–per–hour model).[1]

Bagging and Ties.––Ginning managers experience variations in bagging and tie cost depending on the type of material used and the size bale produced. Some firms with large capacities are able to bargain for a quantity discount although this practice is not common. Previous accounting records were used along with personal interviews to obtain a cost for packaging material of $3.25 per bale. However, the gin model with capacities of 30 bales per hour and greater use automatic strapping machines with preformed cardboard bale coverings. This technique was estimated to reduce packaging material cost to $2.75 per bale for those gins.[2] Per bale costs for packaging material were applied to total gin volume to obtain the total cost for bagging and ties (Table 13).

Energy.––Electricity powers virtually all of the machinery within a modern gin plant. The work done by Looney and Wilmot was used as a guideline for determining energy requirements in this study.[3] The estimates were verified with personnel from the Pacific Gas and Electric Company.[4]

The monthly energy inputs and costs developed for this analysis of ginning costs are summarized in Appendix Table 11. Electricity costs for the season were calculated by multiplying the monthly expense for each gin model by the number of months operated.[5] Pacific Gas and Electric Company rate schedules were the source of unit electrical costs.[6]

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[1] Many gin plants, especially those with off–season activities, hire office help on an annual basis.

[2] Many gins are currently experimenting with an even cheaper bale covering––polyethylene.

[3] U. S. Economic Research Service, *Economic Model . . .*, p. 38.

[4] This company is the principal supplier of electricity for cotton gins in the Valley.

[5] The central ginning system will allow gins to operate at a constant daily rate throughout the operating season. Therefore, it was not necessary to determine daily changes in energy demand. Total electricity use was simply a multiple of the number of months operated.

[6] California, Public Utilities Commission, "Decision No. 78881: General Service–Demand Metered, Schedule A–12, Effective July 1, 1971," Revised California Public Utilities Commission Sheet No. 4902–E (San Francisco: Pacific Gas and Electric); also, Schedule A–13, Revised California Public Utilities Commission Sheet No. 4903–E.

Repairs.––Repair costs vary by gin capacity and annual volume. Repair costs used here were derived from the Looney and Wilmot study and then checked against gin cost accounting records.[1] Per bale repair cost was found to decrease with increasing gin size. Multiple battery gins are simply double sets of equipment and are assumed to have no additional savings in per bale repair cost.

Miscellaneous.––Miscellaneous costs include minor items such as dryer fuel, other utilities, gin and office supplies, travel, advertising, telephone, dues, meetings, auto and truck variable operating expenses, and other items of smaller importance. Costs were estimated based on the Looney and Wilmot study.[2] The estimates were found to be similar to actual costs incurred by Valley ginners. Per bale miscellaneous costs decreased with gin size. In this analysis it was assumed that there were no savings in miscellaneous costs per bale for double–battery plants beyond those associated with each single battery.

Total Variable Cost

The cost of bagging and tie material was the highest variable cost item in all plant models. The other costs calculated on a per bale basis––repair and miscellaneous costs––were the second highest cost item in all gin models except the 7½-, 15–, and 22½–bale–per–hour plants. Table 13 contains a listing of all variables for the 7½–bale–per–hour plant (see Appendix Tables 3–10 for variable costs associated with other models).

Total Annual Fixed and Variable Costs

Fixed and variable ginning costs were summed to obtain the total annual costs for operating a ginning plant for each gin model and length of season (Table 13 and Appendix Tables 3–10). The total cost of operating a ginning plant for a 6–month season varied between $194,855 and $1,358,295 for the nine gin models studied. Total annual cost for an 11–month season ranged from $296,392 to $2,194,696 for the same gin models.

The total cost figures were divided by the annual volume assumed for each gin plant to obtain the total operating cost per bale. In the lengths of seasons studied (6, 9, and 11 months), average ginning costs declined as gin size increased for the single–battery plants (Table 13 and Appendix Tables 3–10). However, there was a slight jump upward in cost between the 45–, the 60–, and the 75–bale–per–hour plants. This break in continuity probably can be attributed to the addition of a separate gin processing line.

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[1] U. S. Economic Research Service, *Economic Model . . .*, p. 10.

[2] *Ibid.*, pp. 17 and 18.

Actual average cost figures decreased from \$15.55 to \$9.07 per bale as gin size increased for the 6–month season. Average costs for the 11–month season were the lowest for each plant model studied. These costs ranged between \$12.90 and \$7.99 as gin size increased. While differences between model costs due to length of season were slight, it should be noted that all seasons studied were considerably longer than existing ginning periods. Any comparison of model ginning costs determined here with costs incurred with shorter seasons would show greater cost differences.

Results of this phase of the analysis indicate that substantial cost reductions are possible with high–capacity ginning plants operating for extended seasons. It is also evident that most of the available economies of scale are exhausted in the lower ranges of plant capacity.

The decreasing costs resulting from fully utilizing larger scale plants can be attributed to the fact that costs of such items as management, equipment, labor, and electricity do not increase in proportion to capacity. In the larger plants these items are often more fully utilized. Longer seasons yield lower unit costs because of the spreading of cost elements that do not vary with the length of season over a larger total output.

Long–Run Total Ginning Costs

A long–run average cost curve or planning curve was derived statistically for each season length as was done for receiving and storage costs. The following long–run total cost equations were derived:

$$TPC_1 = 100{,}597 + 8.548760x$$

$$TPC_2 = 126{,}820 + 7.851870x$$

$$TPC_3 = 143{,}153 + 7.586123x$$

where

TPC_1 = long–run total cotton ginning costs for a 6–month ginning season

TPC_2 = long–run total cotton ginning costs for a 9–month ginning season

TPC_3 = long–run total cotton ginning costs for an 11–month ginning season

and

x = total seasonal volume.

These three equations represent the relationship between annual operating cost and total annual volume ginned when the scale of plant was allowed to vary for each of the three operating seasons specified.

To obtain the long–run cost per bale of ginning, given any of the three operating seasons, the functions TPC_1, TPC_2, and TPC_3 were divided by volume to obtain long–run average total processing cost functions (ATPC). The gin models operating for 11 months yielded the lowest per bale costs for each size gin. This fact is demonstrated in the three long–run average cost curves of Figure 8.

The coefficient of determination, r^2, for each of the above equations was .99. Thus, the three long–run total ginning cost functions closely fit the estimated cost–output points.

The following section utilizes the assembly costs, receiving and storage costs, and ginning costs developed previously to determine the optimum number, size, and location of cotton gins in the San Joaquin Valley, California.

OPTIMUM NUMBER, SIZE, AND LOCATION OF COTTON GINNING FACILITIES IN THE SAN JOAQUIN VALLEY

This section is concerned with estimation of sources and amounts of cotton production in the San Joaquin Valley in 1975, selection of potential plant sites, and specification of the optimum number, size, and location of cotton gin plants in the Valley.

Estimation of Cotton Production in 1975

The prediction of future cotton production is hampered by the seasonal nature of the crop. Before each year's planting, there is no way of accurately predicting the crop. However, the long–run planning model used in this study requires a long–range production estimate.

One method of predicting future production is based on projecting recent production trends. However, in the face of changing government programs, planting techniques, consumption patterns, and prices (all variables affecting planting intentions), it was determined that only limited reliability could be attached to historical patterns as a means of predicting future production.

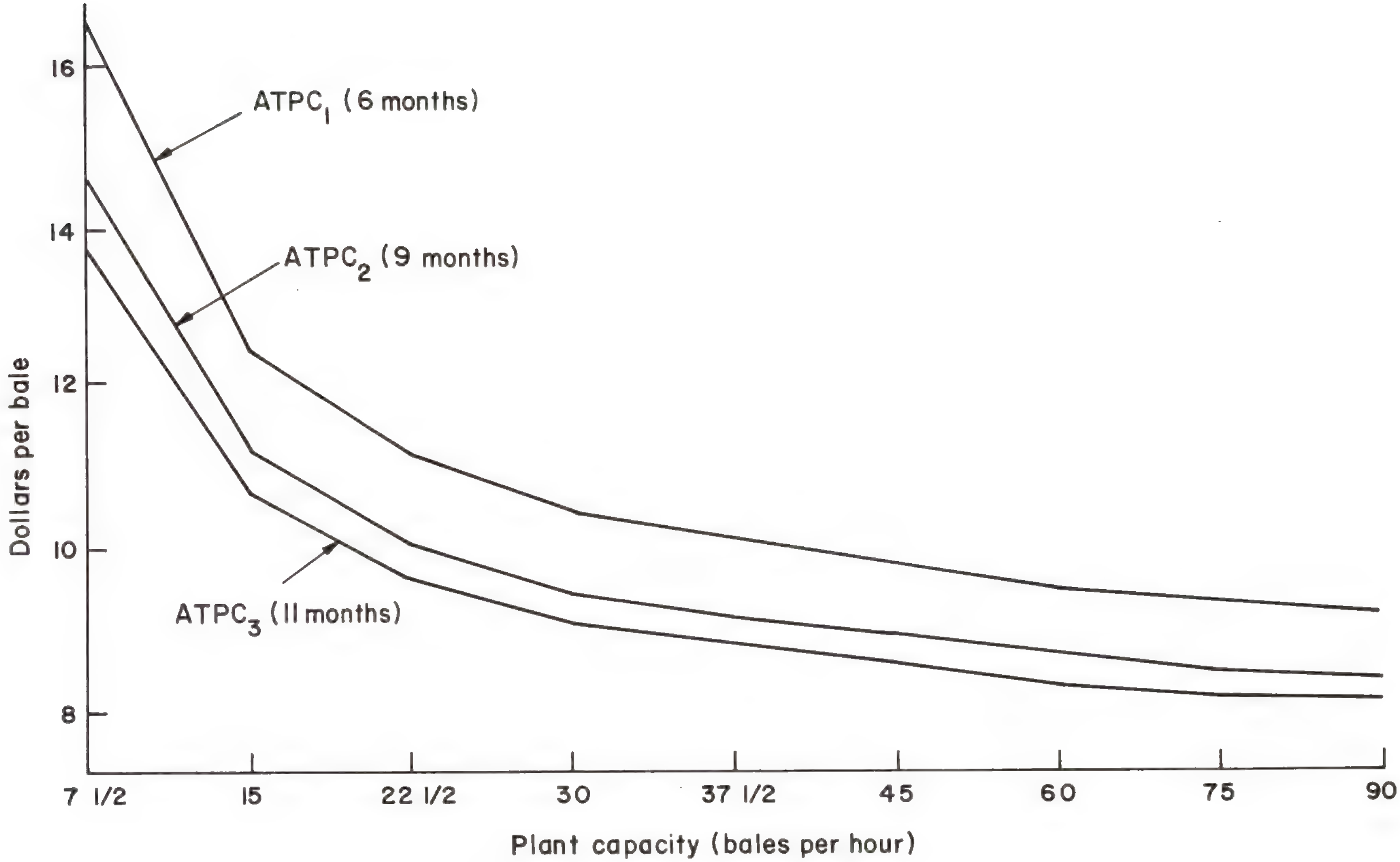

FIGURE 8. Long-Run Average Total Processing Cost for Ginning Cotton, by Rate of Output for 6-, 9-, and 11- Month Ginning Seasons, San Joaquin Valley, California, 1971

A grower survey of planting intentions could provide another means of predicting future plantings. But with 4,106 growers[1] in the Valley, this alternative was also ruled out. Instead, cotton gin managers were chosen to provide production estimates. The managers are knowledgeable about growers' planting intentions in their vicinity and are usually well informed on economic conditions affecting cotton production. During 1971, 10 managers of gin plants located throughout the Valley were selected and asked to supply estimates of 1975 cotton production for the supply areas surrounding their gins. The managers were asked to project future volume based on their own knowledge and after consultation with growers in their areas. Managers were given maps (delineated by townships) of the area surrounding their gins. They were asked to note for each township the number of cotton bales expected to be produced in 1975. They were to take into account the following assumptions concerning the future:

1. The government's role in such areas as acreage control, market quotas, direct payments, etc., would decrease.

2. World price would remain at about the present level.

3. Domestic consumption of cotton would increase slightly.

The results showed a total of 237 townships with some cotton production projected for 1975. This initial set of production densities was labeled as Production Estimate I. County production totals were obtained by summing across townships, and the results are reported in Table 14. Total San Joaquin Valley production in 1975 was estimated at 1,194,285 bales, an increase of 4 percent over the 1967–1971 annual average.

Cotton cannot be grown without a number of conditions present such as water availability, appropriate soil, and, to a certain extent, acreage allotments. For this reason it is highly probable that cotton acreage in the San Joaquin Valley will be limited to the 237 townships mentioned above. However, production totals within given townships could easily prove to be different from the estimates made here. Yields are just one factor that can change significantly year by year making it difficult to project production within an area even after plantings are known. Because of the uncertainties involved in estimating cotton production in the future, alternative production estimates are used to test the sensitivity of the problem solution to changes in production densities.

Production Estimate II was developed to account for possible shifts of production between townships. In this estimate, total production was not changed significantly; and the same 237 townships were used. Information obtained from County Farm Advisors was used to adjust production estimates for individual townships in Fresno, Kern, and Tulare counties. Township estimates in Tulare County were revised downward because of the disease and yield problems currently being experienced. Fresno County township estimates were increased because of expectations of increased acreage and yields by 1975.

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[1] Producers with annual sales over $2,500; see U. S. Bureau of the Census, *Census of Agriculture: 1969, Vol. 1, Area Reports, Part 48, California,* Section 2, County Data, 1972, 456p.

TABLE 14

Cotton Production, 1967-1971, and Cotton Production Estimates for 1975,[a] by County
San Joaquin Valley, California

Year	County						
	Fresno	Kern	Kings	Madera	Merced	Tulare	San Joaquin Valley
	bales						
1967	318,019	258,725	142,544	57,867	35,782	146,696	959,633
1968	409,536	437,858	214,467	75,003	49,094	227,868	1,413,826
1969	366,558	378,628	165,340	65,220	40,099	187,005	1,202,850
1970	310,412	352,159	166,031	53,782	36,288	176,601	1,095,273
1971	292,253	355,234	170,878	42,162	47,141	142,701	1,050,369
Five-year average	339,356	356,521	171,852	58,807	41,681	176,174	1,144,390
1975 production estimate							
I	354,550	306,810	176,850	24,350	36,300	295,425	1,194,285
II	379,630	350,000	176,850	24,350	36,300	200,000	1,167,130
III	474,538	437,500	221,062	30,438	45,375	250,000	1,458,913
IV	284,723	262,500	132,638	18,262	27,225	150,000	875,347

a/ Cotton production figures are reported by the U. S. Bureau of the Census only in running bales. This is a measure of the actual number of bales pressed; the weight per bale varies.

Sources

1967-1971: U. S. Bureau of the Census, Cotton Production in the United States: Crop of 1966 (1967), and subsequent annual issues.

1975: Selected San Joaquin Valley cotton gin managers and county farm advisors.

Production in selected Kern County townships was revised upward due to expected expansion of cotton acreage in the western part of the county as irrigation water is made available. Based on Production Estimate II, total cotton production in the San Joaquin Valley in 1975 is expected to total 1,167,130 bales, 2 percent greater than the 1967-1971 average annual production (Table 14).

Two other production estimates are also included in the study. In these estimates the spatial pattern of production is the same as in Production Estimate II, but the level of production is altered uniformly for all townships. In Production Estimate III, total production in each township is increased by 25 percent from the production used in Production Estimate II, while in Production Estimate IV, total production in each township is decreased by 25 percent. These variations result in an estimated production for 1975 of 1,458,913 bales and 875,348 bales for Production Estimates III and IV, respectively (Table 14).

All four production estimates were used to demonstrate the sensitivity of the problem solution to variations in total production. However, only the solution using Estimate II is reported in detail.[1] The problem solution using Estimate II is also used to compare costs of the long–run, cost–minimizing industry organization to costs incurred under the present industry structure.

Potential Plant Locations

An infinite number of locations can be considered as possible gin sites in the San Joaquin Valley. To narrow the field of choices to a reasonable size, some restrictions were made. The first of these restrictions was to select potential locations adjacent to towns or trade centers on major roads. The second restriction was that the sites had to be adjacent to a railroad line. Both restrictions were based on the fact that cotton is hauled to the gins by truck and is usually transported to the domestic mill by rail.[2] Subject to the first two restrictions, the third restriction was to select plant sites that are presently sites of existing gins, warehouse facilities, and/or cottonseed oil mill facilities. Although this method of selecting potential plant sites is largely arbitrary, the selection procedure does recognize practical considerations in plant location.

The 14 plant sites chosen are spatially dispersed throughout the main cotton producing areas of the Valley (Figure 9). All sites chosen are locations of existing ginning plants and, in some cases, warehouses. The sites selected are located near the following towns:

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[1] Production estimates by township can be obtained from the authors.

[2] A large portion of cotton in the Valley is also trucked to nearby ports for export.

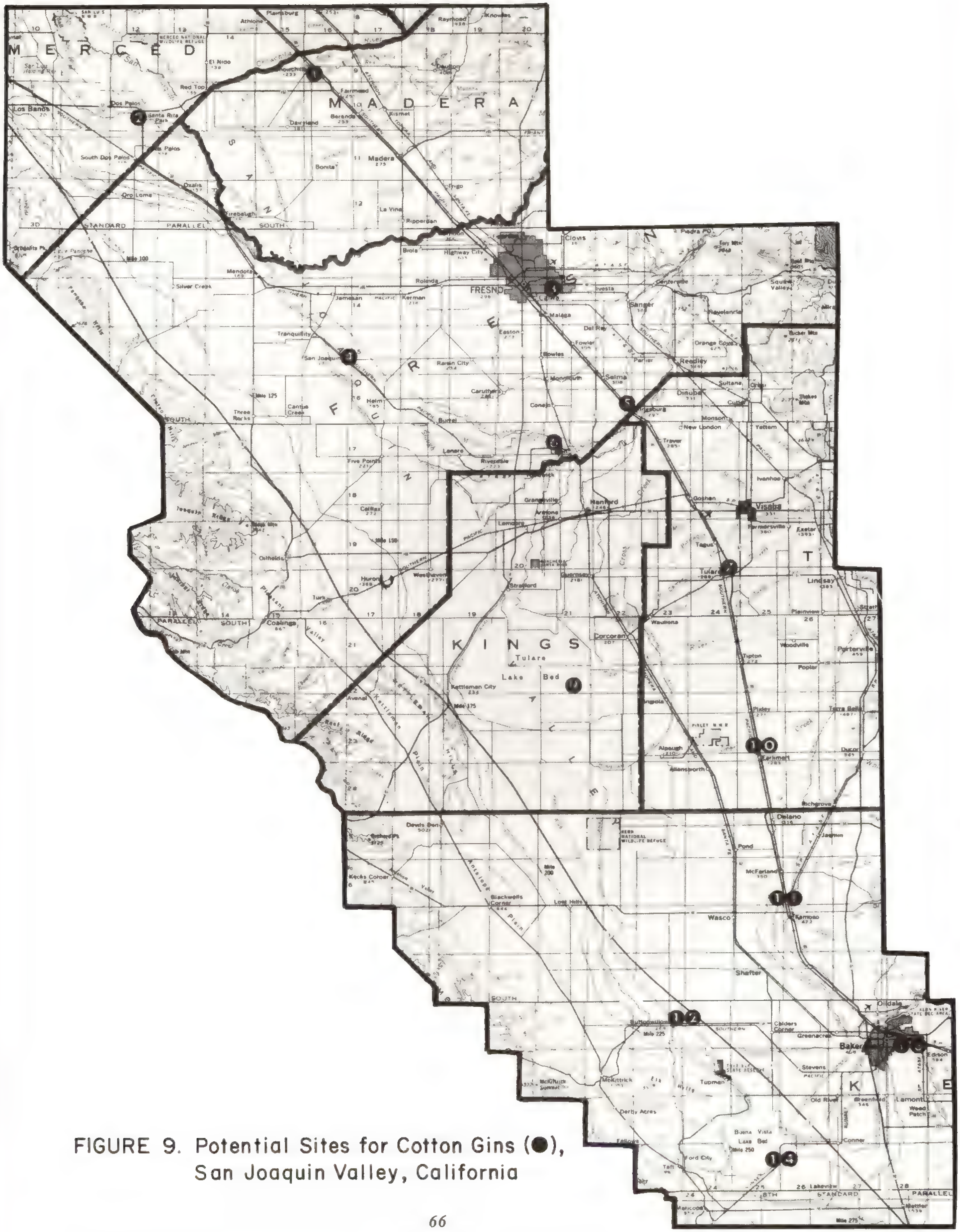

FIGURE 9. Potential Sites for Cotton Gins (●), San Joaquin Valley, California

1. Chowchilla	8. Huron
2. Dos Palos	9. Corcoron
3. Fresno	10. Earlimart
4. San Joaquin	11. Famoso
5. Kingsburg	12. Buttonwillow
6. Laton	13. Bakersfield
7. Tulare	14. Buena Vista

The numbers above correspond to those in Figure 9.

Determination of the Optimum Number, Size, and Location of Cotton Ginning Facilities in the San Joaquin Valley, 1975

The analytical model used in obtaining the optimum number, size, and location of plants has been described previously. This section uses the cost structures already developed to solve for the optimum number, size, and location of cotton ginning facilities in the San Joaquin Valley in 1975.

As noted previously, the model can be utilized with any of four conditions pertaining to the existence or nonexistence of economies of scale in the plant operation and the effect of location on plant costs. Based on the plant cost estimates obtained, the condition of economies of scale in the plant operation with no difference in plant cost due to location was selected. Economies of scale in storage and processing costs were clearly evident from the cost functions generated. Furthermore, the cost of labor, electricity, bagging, and ties as well as other variable costs was found to be similar throughout the Valley.

The solution procedure can be separated into three steps.[1] First, the minimized total assembly cost is found for plant numbers ranging from 1 to 14. Second, the total receiving, storage, and ginning cost function showing how these costs vary as the number of plants varies is determined. Third, the assembly and receiving, storage, and ginning costs are combined for each number of plants. That number of plants requiring the least total cost is the problem solution.

Minimized Total Assembly Costs.—Air distances between the center of each of the 237 production sources and each of the 14 potential plant sites were calculated. These air distances were adjusted to road distances by means of the following regression equation:[2]

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[1] A detailed description of the solution procedure is supplied in Stollsteimer, "The Effect of Technical Change and Output. . . ."

[2] The equation was derived from a sample of actual road miles in the production area.

$$R = .286 + 1.174A \qquad r^2 = .9839$$

where R is road miles and A is air miles.

The road mileages calculated using the above equation were used in conjunction with the assembly costs derived earlier to obtain an assembly cost matrix showing the cost of transporting one lint–equivalent bale of seed cotton in hay–size bales from each production origin to each potential plant site (see Table 3 for the schedule of unit costs used in the calculation). Township production estimates making up Production Estimate II were used in conjunction with the assembly cost matrix to determine the total assembly cost for all possible combinations of plants.

Total Storage and Processing Costs.––Cost functions (TSC_1, TSC_2, and TSC_3) for receiving and storage operations with seed cotton and cotton lint were developed previously. Three seasonal lengths were considered––6, 9, and 11 months. Processing cost functions (TPC_1, TPC_2, and TPC_3) were also derived previously for the same three seasonal lengths based on plant operation of five days per week and two 8–hour shifts per day.

A long–run total cost function for receiving, storage, and processing costs was derived for each of the three seasonal lengths. The following functions $TSPC_1$, $TSPC_2$, and $TSPC_3$ are the sums of TSC_1 and TPC_1, TSC_2 and TPC_2, and TSC_3 and TPC_3, respectively:[1]

$$TSPC_1 = 125{,}661 + 11.405416x$$

$$TSPC_2 = 155{,}927 + 10.762932x$$

$$TSPC_3 = 173{,}714 + 10.520593x$$

where

$TSPC_1$ = long–run total receiving, storage, and ginning costs for a 6–month ginning season

$TSPC_2$ = long–run total receiving, storage, and ginning costs for a 9–month ginning season

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[1] When adding cost functions, the seasonal length of each receiving and storage facility had to correspond to the seasonal length of each ginning facility. This would allow the two facilities to operate as a unit.

$TSPC_3$ = long–run total receiving, storage, and ginning costs for an 11–month ginning season

and

x = total seasonal volume.

For any given seasonal volume, the above long–run total cost functions can be used to determine the length of operating period which results in minimum total season costs. For seasonal volumes of less than approximately 47,000 bales, the 6–month operating schedule yields total season costs which are less than with either the 9– or 11–month operating schedules. For seasonal volumes of greater than approximately 73,000 bales, the 11–month operating schedule yields lowest total season cost. For seasonal volumes between 47,000 and 73,000 bales, the 9–month operating schedule results in lowest total season costs. Thus, the optimal length of the operation period is dependent upon total seasonal volume. In solving for the cost–minimizing number, size, and location of cotton gins in the San Joaquin Valley, the length of operating period is selected which results in lowest total season costs.

Optimal Number, Size, and Location of Facilities.——All the data required to solve for the cost–minimizing number, size, and location of cotton gins in the San Joaquin Valley have now been developed. Table 15 summarizes the individual cost components for plant numbers ranging from 1 to 14 and provides the information needed to obtain the problem solution.

If only a single cotton gin were to be operated in the San Joaquin Valley in 1975, the quantity of cotton ginned by that plant would total 1,167,130 bales or the entire amount of cotton estimated to be produced in the Valley. Total assembly costs would be minimized if the single plant were located at Corcoran and would total \$3,971,283. For a single plant located at any of the other 13 potential plant sites considered, total assembly costs would be greater than \$3,971,283. Selection of Corcoran as the cost–minimizing single plant location seems plausible on an intuitive basis since it is centrally located in the San Joaquin Valley cotton producing region (Figure 9).

If two cotton gins were to be operated in the San Joaquin Valley in 1975, total assembly costs would be minimized if the plant locations were Earlimart and San Joaquin. With these plant locations, total assembly costs would be \$3,458,768 compared with \$3,971,283 for the single plant solution. A total of 681,895 bales would be ginned at Earlimart, and 485,235 bales would be ginned at San Joaquin.

Minimized total assembly costs for plant numbers ranging from 3 to 14 are also reported in Table 15 along with the quantity of bales ginned at each plant location. Minimized total assembly costs continue to decrease as plant numbers increase but at a decreasing rate.

TABLE 15

Minimized Total Assembly Costs (Using Production Estimate II); Total Receiving, Storage, and Processing Costs (11-Month Season); and Combined Costs for Each of 14 Possible Plant Solutions Including Product Allocations in Bales for Each Plant Solution San Joaquin Valley, California, 1971

Potential plant location	Number of plants						
	1	2	3	4	5	6	7
	bales						
Bakersfield			298,858				
Buena Vista				230,492	230,492	230,492	230,492
Buttonwillow							
Chowchilla							
Corcoran	1,167,130		503,158	344,665		197,370	197,370
Dos Palos					158,816	158,816	104,668
Earlimart		681,895		226,859	315,081	222,695	222,695
Famoso							
Fresno							
Huron					298,442	205,478	141,177
Kingsburg					164,299	152,279	116,915
Laton							
San Joaquin		485,235	365,114	365,114			153,813
Tulare							
	dollars						
Total assembly cost	3,971,283	3,458,768	3,161,375	3,049,896	2,940,746	2,855,148	2,787,120
Receiving, storage, and processing costs[a/]	12,452,614	12,626,328	12,800,042	12,973,756	13,147,470	13,321,184	13,494,898
Combined cost	16,423,897	16,085,096	15,961,417	16,023,652	16,088,216	16,176,332	16,282,018
	Number of plants						
	8	9	10	11	12	13	14
	bales						
Bakersfield				83,644	83,644	83,644	83,644
Buena Vista	137,385	137,385	134,647	64,466	64,466	64,466	64,466
Buttonwillow	139,889	139,889	82,383	82,383	82,383	82,383	82,383
Chowchilla							25,075
Corcoran	187,671	174,131	174,131	174,131	174,131	171,631	171,631
Dos Palos	104,668	104,668	104,668	104,668	104,668	104,668	82,993
Earlimart	185,612	148,039	86,994	86,994	86,994	86,994	86,994
Famoso			121,289	107,826	107,826	107,826	107,826
Fresno					61,742	51,025	48,325
Huron	141,177	141,177	141,177	141,177	141,177	135,677	135,677
Kingsburg	116,915	83,993	83,993	83,993	59,880	32,176	32,176
Laton						46,421	46,421
San Joaquin	153,813	153,813	153,813	153,813	116,184	116,184	115,484
Tulare		84,035	84,035	84,035	84,035	84,035	84,035
	dollars						
Total assembly cost	2,728,688	2,700,570	2,679,134	2,661,654	2,649,333	2,640,861	2,632,484
Receiving, storage, and processing costs[a/]	13,668,612	13,842,326	14,016,040	14,187,589	14,355,203	14,528,917	14,650,228
Combined cost	16,397,300	16,542,896	16,695,174	16,849,243	17,004,536	17,169,778	17,282,712

a/ Volume allocated to each plant site determines optimum seasonal length at each site as follows:

Volume	Seasonal length
Less than 47,000 bales	6 months
Greater than 47,000 bales but less than 73,000 bales	9 months
73,000 bales or greater	11 months

Seasonal length determines the long-run total receiving, storage, and ginning cost function applicable in calculating these costs.

Source: Calculated.

The long–run costs of receiving, storage, and processing cotton are also reported in Table 15 for plant numbers ranging from 1 to 14. Given that factor prices are uniform at all of the potential plant locations, total industry long–run plant costs increase with the number of plants by an amount equal to the intercept value of the appropriate seasonal length long–run plant cost function. For solutions involving 10 or fewer plants, the volume processed at each plant location is in the range for which the 11–month operating period yields lowest total plant costs. Consequently, for the solutions involving 10 or fewer plants, plant costs are reported based on use of the 11–month operating schedule. For solutions involving 11 or more plants, plant costs for each location are based on use of the operating schedule which provides minimum total season costs for the volume processed at that location.

The last row of Table 15 shows the combined assembly and plant costs for each number of plants. For the single plant solution, combined assembly and plant costs are estimated to total $16,397,300. Total combined costs decrease for the two–plant solution and decrease still further for the three–plant solution.

The combined receiving, storage, processing, and minimized assembly costs rise at an increasing rate when the number of plants is increased beyond three. Increases in average processing costs generated by smaller scale plants more than offset decreasing assembly costs as the number of plants increases. Apparently, though, the offset is slight. Even when 14 plants are included in the solution, combined cost is only 9 percent larger than for the three–plant solution. However, the solution involving three plants––one each at Bakersfield, Corcoran, and San Joaquin––is obtained as the cost–minimizing solution. A total of 298,858 bales are ginned at Bakersfield, 503,158 bales are ginned at Corcoran, and 365,114 bales are ginned at San Joaquin. Minimized total assembly cost with this solution is $3,161,375.

Plant costs for the optimal three–plant solution are based on use of the 11–month operating schedule and total $15,961,417. Hourly ginning capacity required at each of the three locations is as follows: Bakersfield, 83 bales per hour; Corcoran, 140 bales per hour; and San Joaquin, 102 bales per hour. The size of the plant required at Corcoran and San Joaquin is larger than any plant considered in the plant cost analysis. However, since plant size is increased by the addition of gin batteries, costs of which have been studied, extrapolation of the long–run total plant cost function developed previously seems applicable.

The above solution for the number, size, and location of plants required to assemble and gin the 1975 cotton crop in the San Joaquin Valley at least cost is based on the use of Production Estimate II. It remains to obtain the problem solution using Production Estimates I, III, and IV to determine the sensitivity of the solution to changes in the level of cotton production in the Valley.

A summarization of results obtained when the problem solution is rerun using Production Estimates I, III, and IV is presented in Table 16. For each of the three production estimates, the optimal solution involves a total of three plants, one each at Bakersfield, Corcoran, and San Joaquin. This is the same result as obtained when Production Estimate II was used. Of course, total volume ginned and hourly ginning capacity required at each location differ from results obtained when Production Estimate II was used.

The comparison of results obtained when alternative cotton production estimates are used shows that the problem solution is not greatly sensitive to changes in cotton production, at least over the range in production considered. In this study, Production Estimate II is considered to be the most appropriate; and results obtained using this production estimate are used as specifying the number, size, and location of cotton gin plants required to assemble and process the 1975 San Joaquin Valley cotton crop at least cost.

Comparison of Present Industry Costs with Costs for the Long–Run Optimum Industry Organization

Currently, there are 212 gin plants in the Valley, most of which have capacities under 10 bales per hour. If the 1971 cotton production in the Valley were to be distributed equally, each gin would have received only 4,955 bales. This volume contrasts sharply with the 83–bale–per–hour capacity (298,858 bales per annum) required at even the smallest of the plants in the optimum solution. Further, the cost–minimizing solution would require not only adjustments in the number, size, and location of plants but also the adoption of new practices such as seed cotton storage and sampling. The model gin plants studied here also use the most modern gin equipment, while most of the plants now in existence do not make use of such equipment. It is informative to consider what the annual opportunity costs of not achieving this long–run optimum solution would be both on a per bale basis and as a total cost for all cotton producers in the Valley.

The steps and costs required in getting seed cotton ready for commercial use in both the present system and the optimal system, as described in this report, are presented in Table 17. Important differences in the two systems exist. The optimum system requires seed cotton baling, seed cotton storage, and greatly reduced ginning costs and does not require hauling between gin and compress, lint storage (in the 11–month model), or compression changes.

Costs for the optimum solution are based on the three–plant solution using Production Estimate II, with the 11–month storage and ginning season described previously. The total baling, stacking, loading, assembly, receiving, storage, and ginning cost would be $17.24 per bale if the optimum solution were adopted Total costs for all assembly, ginning, and storage under the conventional system were estimated at $32.41. The difference between the traditional and optimal systems is $15.17 per bale.

TABLE 16

Results of Analysis to Determine the Cost-Minimizing Number, Size, and Location of Plants Required to Assemble and Gin the 1975 San Joaquin Valley Cotton Crop Using Alternative Cotton Production Estimates

Production estimate	1975 estimated total cotton production	Cost-minimizing specifications						
		Number of plants	Total assembly cost	Total receiving, storage, and processing cost	Total combined cost	Plant locations	Total volume ginned	Hourly ginning capacity required[a]
	bales		dollars				bales	bales per hour
I	1,194,285	3	3,247,503	13,085,728	16,333,231	Bakersfield	267,310	74.5
						Corcoran	581,825	162.0
						San Joaquin	345,150	96.0
III	1,458,913	3	3,951,719	15,869,771	19,821,490	Bakersfield	373,573	104.1
						Corcoran	628,948	175.2
						San Joaquin	456,392	127.2
IV	875,348	3	2,371,031	9,730,322	12,101,353	Bakersfield	224,143	62.5
						Corcoran	377,369	105.1
						San Joaquin	273,836	76.3

a/ Productive capacity--85 percent of manufacturer's rating.

Source: 1975 production estimates from selected San Joaquin Valley cotton gin managers and county farm advisors; all other figures calculated.

TABLE 17

Comparison of Conventional and Optimum Farm-to-Warehouse Costs Per Bale for Cotton
San Joaquin Valley, California, 1971[a]

	Ginning system	
	Conventional	Optimum
	dollars per bale	
Baling and stacking infield	b/	3.19[c]
Hauling from farm to gin	3.99[d]	3.09[e]
Seed cotton receiving and storage	f/	3.01[g]
Ginning	22.78[h]	7.95[i]
Hauling lint to compress-warehouse	1.15[j]	k/
Lint storage and compression	4.49[l]	m/
Total unit cost	32.41	17.24
Total annual cost	37,826,683	20,121,321

a/ Based on Production Estimate II--1,167,130 bales.

b/ Not required in conventional ginning system.

c/ Lint-equivalent bale (Table 2, *supra*, p. 26).

d/ Six-bale trailers used nine times per year for an average round trip of 20 miles (Looney and Wilmot).

e/ Seed cotton bales hauled on flatbed trucks for an average haul of 25 miles. Power-operated loaders perform 50 percent of the loading at the field. Represents an average one-way haul of 25 miles. Derived from the three-plant optimum solution.

f/ Receiving costs under the present system consist of the driver's wages while at the gin yard and while unloading the trailer at the suction pipe. The former cost is included in the cost of assembly; the latter cost is included in the cost of ginning.

g/ Derived from the three-plant optimum solution, equation TSC_3.

h/ Ginning charges do not necessarily correspond to ginning costs when calculating the ginning charge. The charge stated here is, however, a close approximation to actual ginning costs in the San Joaquin Valley (U. S. Economic Research Service and Agricultural Marketing Service).

i/ Derived from the three-plant optimum solution, equation TPC_3.

j/ Based on an average haul of 50-60 miles. Derived from rates used by major trucking company.

k/ Not required in optimum ginning system.

l/ Derived from Ghetti and Chandler.

m/ Since a ginning season of 11 months is used in the optimum system, there is no need for lint storage. The use of universal density gin presses would eliminate the need for compression charges.

Sources:

Zolon M. Looney and Charles A. Wilmot, Economic Models for Cotton Ginning, U. S. Economic Research Service, Agricultural Report No. 214 (Washington, D. C., 1971), p. 23.

U. S. Economic Research Service and Agricultural Marketing Service, Charges for Ginning Cotton, Costs of Selected Services Incident to Marketing, and Related Information, ERS-2 (1972).

Joseph L. Ghetti and Whitman M. Chandler, Jr., Cost of Storing and Handling Cotton at Public Storage Facilities, 1969-70, with Projections for 1971-72, U. S. Economic Research Service, ERS-472 (Washington, D. C., 1971), 37p.

On a relative basis, this means that a reduction in costs of 47 percent is possible with the optimum industry organization. Thus, a substantial opportunity cost exists for not adopting the minimum cost assembly and storage techniques and the associated optimum number, size, and location of plants as suggested in this study. This opportunity cost is $17,705,362 annually for San Joaquin Valley cotton producers.

The savings result from a combination of factors. Economies possible in high ginning capacity and a longer ginning season would yield most of the savings. But to achieve these savings, they must be incorporated with a totally new system of cotton handling from farm to compress. Thus, the use of new techniques such as seed cotton baling, assembly, storage, and universal density compression, as well as shortened periods of lint cotton storage, are all necessary if ginning economies are to be achieved.

An analysis was conducted to determine the length of time it would take for the annual savings of $17,705,362 to recover the cost of investment in the three ginning and warehousing facilities. The cost of building the optimal facilities was determined using the following criteria:

1. Ginning batteries with a productive capacity rating under 25.5 bales per hour were not used at any of the locations.

2. The plant models chosen for each site represented the combination of plants coming closest to the required total capacity. Where combinations were tied for closest total capacity, the one with the least cost was chosen for the site.

Using the above criteria and the investment costs developed earlier for storage and ginning facilities, the following combinations of plants (using Production Estimate II) were chosen for the 140–, 102–, and 83–bale–per–hour productive capacity required at the three facilities:

Required total productive capacity, bales per hour	*Total cost, dollars*
140	12,302,310[a]
102	9,095,345[b]
83	7,736,495[c]
Total	29,134,150

[a] Based on construction of plants with 76.5– and 63.8–bales–per–hour capacities.

[b] Based on construction of plants with 76.5– and 25.5–bales–per–hour capacities.

[c] Based on construction of plants with 51– and 31.9–bales–per–hour capacities.

An additional investment in feeder wagons and balers is required. Total investment for this equipment is estimated at $9,000,000.[1]

The total capital outlay required for baling equipment and storage and ginning facilities is $38,134,150. This investment sum does not include payoff of existing debt among ginning facilities that might occur if the ginning industry invested in a new system. With an annual savings of $17,705,362 over the present system, the payout period would be completed by the end of the third year.

The problem solution developed in the study and on which the above cost comparisons are made is based on a long–run analysis. Costs for the optimal solution were calculated based on construction and operation of new plants, and no consideration was given to utilization of existing ginning facilities. Practically, however, existing facilities might be incorporated into the optimum solution.

The three locations specified in the optimum solution are presently sites of cotton gins, but the existing facilities are not as large as required to achieve minimum industry costs. Expansion of ginning capacity at these sites would be required to obtain the necessary capacities. As a result of utilizing existing facilities, investment requirements and fixed costs associated with investment in facilities would be less than calculated for the optimum solution resulting in larger savings over present industry costs. However, since the existing gin batteries at these locations are smaller in size than specified in the optimum solution, variable costs would be increased, offsetting some portion of increased savings. Thus, although detailed cost comparisons were not made, use of existing ginning facilities as part of the optimal solution is not expected to have a great influence on the level of total costs incurred.

SUMMARY

The objective of this study was to estimate the number, size, and location of cotton gins required to minimize the total costs of assembling and ginning cotton produced in California's San Joaquin Valley. To achieve this objective, several modifications to current cotton assembly and ginning operations were considered. The first such modification involved the use of hay balers to bale seed cotton in the field. This technique reduces assembly cost since baled seed cotton is less costly to transport than cotton in loose form.

The second modification involved lengthening the cotton gin operating season. Presently, cotton gins in the San Joaquin Valley operate sporadically for only three to four months per year. In this study, operating periods of 6, 9, and 11 months were

[1] Based on a seasonal volume of 975 bales for each wagon and baler, a total of 1,200 wagons and 1,200 balers is required.

considered. Increasing the operating season requires that cotton be stored prior to ginning. Consequently, costs of building and operating seed cotton storage facilities were estimated.

Finally, ginning costs for nine model ginning plants were estimated for each of the three different operating periods.

Using the cost estimates for cotton assembly, storage, and ginning, along with estimates of 1975 cotton production in the San Joaquin Valley, a two–stage procedure was used to estimate the optimum number, size, and location of cotton gins in the Valley. Three gins were found to yield the lowest total assembly, storage, and ginning costs. Locations of these plants at Bakersfield, Corcoran, and San Joaquin were indicated.

Total costs for assembly, storage, and ginning of cotton in the San Joaquin Valley for 1975 were estimated to be $15,961,417. This cost does not include costs of in–field baling or loading. If these costs are included, total costs are $20,121,321 which is 47 percent less than the estimated $37,826,683 currently expended to assemble and gin cotton in the Valley. While a substantial capital outlay is required to construct three plants of the size indicated to yield minimum total industry costs, estimated savings resulting from such a reorganization of plant facilities in the San Joaquin Valley would be sufficient to justify the necessary investment.

Limitations of the Study

The assumption was made in this study that seed cotton can be stored for extended time periods. Technical problems associated with seed cotton storage have been studied in the past. The practice has been found to be technically feasible providing the proper precautions are taken. However, more research needs to be done on the best methods for storing seed cotton, especially for extended time periods.

Several of the other limitations to this study are inherent in all studies using the Stollsteimer model. These limitations concern the static nature of the solution procedure. The optimum number, size, and location of plants vary with changes in cost patterns, production patterns, or potential plant sites.

Cost–volume relationships for cotton ginning facilities also have been studied extensively. However, neither gin processing lines capable of ginning over 36 bales per hour nor the economies associated with large multiple processing lines have been studied previously.

In–field preparation and assembly methods utilized in this study are not currently practiced in the cotton industry. As a result, their costs could only be approximated. Additional research is needed on the feasibility of alternative methods for performing these functions in a system of fewer gins and extended ginning seasons.

Cotton production estimates are the source of another possible limitation in the study. Because of many uncertainties inherent in cotton production, the size of the 1975 crop could differ from the volume estimated using Production Estimate II. In order to consider the effects of variation in the level of total production on the optimum solution, the problem was rerun using three alternative production estimates. For each of these production estimates, the optimum number and location of plants were the same as when Production Estimate II was used.

Another problem with the static analysis conducted here involves the selection of the 14 potential plant sites. It should be recognized that another set of locations could have been selected that might have been equally appropriate.

Implications

Results of this study indicate that, if long–run industry costs are to be minimized, a substantial reduction in the number of cotton gins in the San Joaquin Valley is required. With a total of only three ginning plants in the Valley, each plant would have a degree of monopsony power since cotton producers would have little opportunity to sell to other gins. For this reason, a larger number of plants might prove to be a more acceptable solution when goals other than least cost are considered. As Waugh has stated, "the public may prefer to keep some known efficiencies, rather than to adopt new methods––especially if the prospective improvements in efficiency might reduce employment, decrease price competition, or lead to greater concentration of economic power."[1]

Nevertheless, for the cotton ginning industry, cost efficiency is an important consideration. Reduction of the number of gins would allow the remaining gins to obtain the higher volumes necessary to justify high–capacity plants and extended operating seasons. Attention needs to be directed toward a means by which cost reductions in assembly and ginning of cotton can be achieved and at the same time producers assured that charges for ginning services accurately reflect costs of providing the services.

Given that significant cost savings are possible from reorganization of the cotton ginning industry in the San Joaquin Valley, the next consideration is how to move from the existing organization to the optimum organization. Since many of the existing cotton gins are farmer cooperatives, one approach might involve a merger of the existing cooperatives into a single organization. Such an organization would have the ability to establish the optimum facility configuration, perhaps using existing facilities wherever possible. This approach would yield the maximum savings in the shortest time. However, it is likely that the rapid and widespread closing of gins would meet with substantial resistance from some gin managers and growers.

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[1] Frederick V. Waugh (ed.), *Readings in Agricultural Marketing* (Ames, Iowa: The Iowa State College Press, 1954), p. 195.

A second approach to the problem would be to make the adjustment slowly over a period of several years. Older and smaller processing plants would be gradually closed and replaced by plants consistent with the long–run optimum solution derived here. Eventually, the ginning industry would evolve toward the optimum situation; but the full cost savings indicated in this study would not be available until adjustment was complete. It is likely that this approach would never result in the full cost savings estimated since there is no assurance that the optimal number, size, and locations could be achieved through decisions made by numerous individuals acting independently.

The San Joaquin Valley cotton industry has already begun experimenting with improved methods of preparing seed cotton for the fiber market. Innovations have been in the areas of seed cotton storage, transportation, ginning, and bale packaging.

Ginners have always faced the problem of matching harvesting rates to ginning rates. Previously, this problem was solved either by holding seed cotton trailers on the gin yard or by constructing additional facilities. Recently, ginners and growers have begun to realize that it is practical to store seed cotton on the turn row for several weeks at a time. The seed cotton is then picked up and ginned when harvest rates have tapered off. Few instances of quality deterioration have been reported, and the practice is becoming more widespread each year.

Methods of financing are being altered to provide additional incentives for the farmer to temporarily store his seed cotton. The U. S. Department of Agriculture seed cotton loan program, mentioned earlier in this report, is one example. One cooperative in Texas even provides the farmer an advance payment on stored seed cotton based on a representative example. The use of forward contracting is becoming a popular method for the grower to receive a guaranteed price for his product before harvest. This can lessen the fear of market price fluctuation during the seed cotton storage periods.

Existing gins are being replaced with gins having fewer and larger gin batteries. A universal density bale has recently been accepted by the industry. In addition, materials are now available to reduce the cost and improve the appearance of the bale package.

Follow–up studies are now being conducted in the San Joaquin Valley to lay the groundwork for mergers of cooperative ginning firms. Presently, several cooperative gins are interested in merger and have requested that an economic feasibility study be done to determine the best configuration of plants for the merged firm.

The reorganization of the ginning and warehousing industry has implications beyond those analyzed here. With the larger concentrations of cotton at each gin, numerous possibilities would exist for increased efficiencies in the total system of moving cotton from farm to mill.[1] The optimum network of ginning and warehousing facilities proposed here can serve as a focal point for a more efficient cotton marketing system.

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[1] U. S. Farmer Cooperative Service, *A Producer–Based Cotton Marketing System,* by James E. Haskell, Marketing Research Report No. 1016 (1972), 27p.

A P P E N D I X

APPENDIX TABLE 1

Annual Depreciation Costs for Receiving and Storage Facilities
by Ginning Capacity and Length of Season
San Joaquin Valley, California, 1971

Cost item	Annual depreciation rate	Plant capacity (bales per hour)[a]								
		7½	15	22½	30	37½	45	60	75	90
	percent	dollars								
6 months										
Buildings[b]	3.33	4,857	9,715	13,115	17,487	21,859	26,231	34,975	43,718	52,462
Water tower	2.5	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313
Pavement	5.0	1,103	2,205	2,977	3,969	4,961	5,954	7,938	9,922	11,908
Sample gin[c]	6.66	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056
Total		9,329	15,289	19,461	24,825	30,189	35,554	46,282	57,009	67,739
9 months										
Buildings[b]	3.33	9,715	15,301	24,045	30,603	39,346	45,904	61,205	76,507	91,808
Water tower	2.5	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313
Pavement	5.0	2,205	3,473	5,457	6,946	8,930	10,419	13,892	17,364	20,837
Sample gin[c]	6.66	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056
Total		15,289	22,143	32,871	40,918	51,645	59,692	78,466	97,240	116,014
11 months										
Buildings[b]	3.33	12,144	19,673	30,603	39,346	50,276	59,019	78,693	98,366	118,039
Water tower	2.5	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313	1,313
Pavement	5.0	2,756	4,465	6,946	8,930	11,411	13,395	17,861	22,326	26,791
Sample gin[c]	6.66	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056	2,056
Total		18,269	27,507	40,918	51,645	65,056	75,783	99,923	124,061	148,199

a/ Manufacturer's rating.

b/ Includes sprinklers, foundation, humidifiers, and warehouses.

c/ Includes moisture meter.

Source: Calculated.

APPENDIX TABLE 2

Annual Depreciation Costs for Model Ginning Plants Equipped for Processing Machine-Picked Cotton by Major Capital Components and Plant Capacity[a]
San Joaquin Valley, California, 1971

Capital components	Annual depre- ciation rate	Plant capacity (bales per hour)								
		7½	15	22½	30	37½	45	60[b]	75[b]	90[b]
	percent	dollars								
Gin buildings[c]	3.33	1,705	2,098	2,144	2,500	2,930	3,673	5,001	5,861	7,692
Gin machinery[d]	6.66	21,991	31,868	39,966	50,629	56,537	62,633	93,230	112,687	124,582
Office	10.0	880	945	1,010	1,085	1,145	1,210	1,260	1,310	1,365
Office equipment	10.0	400	420	450	470	505	525	555	590	620
Truck scales	5.0	525	525	525	525	525	525	525	525	525
Paving	5.0	1,985	2,625	3,280	3,940	4,590	5,250	5,645	6,040	6,560
Fire protection	5.0	105	105	105	105	105	105	105	105	105
Tools	20.0	420	630	840	1,050	1,260	1,470	1,890	2,310	2,730
Rail siding	3.33	305	305	305	350	350	400	490	540	580
Car, truck[e]	20.0	630	630	630	630	630	630	945	945	945
Total		28,946	40,151	49,255	61,284	68,577	76,421	109,646	130,913	145,704

a/ Based on capital requirements listed in Table 10, using the straight-line depreciation method. Sales tax included in investment costs where applicable. Plant capacity is defined as manufacturer's rating.

b/ Plants with two processing lines each of half the total capacity.

c/ Includes installation, foundation, and seed collection facilities.

d/ Includes freight, installation, trash collection equipment, and all gin machinery.

e/ Salvage value of 25 percent of initial investment.

Source: Calculated.

APPENDIX TABLE 3

Estimated Annual Fixed and Variable Costs for a 15-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	79,673	79,673	79,673
Supervision	18,300	18,300	18,300
Total	97,973	97,973	97,973
Variable costs			
Office help[c]	4,200	7,400	7,400
Plant labor	43,744	65,615	80,197
Electrical energy	16,785	25,178	30,773
Bagging and ties[d]	81,432	122,148	149,292
Repairs[e]	37,083	55,624	67,985
Miscellaneous[f]	41,092	61,638	75,335
Total	224,336	337,603	410,982
Total fixed and variable costs	322,309	435,576	508,955
Fixed cost per bale	3.91	2.60	2.13
Variable cost per bale	8.95	8.98	8.95
Total cost per bale	12.86	11.58	11.08
Seasonal volume (bales)	25,056	37,584	45,936

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Two employees--one 8 hours per day and one 4 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ \$3.25 per bale for jute.

e/ \$1.48 per bale.

f/ \$1.64 per bale.

Source: Calculated.

APPENDIX TABLE 4

Estimated Annual Fixed and Variable Costs for a 22½-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	97,344	97,344	97,344
Supervision	36,300	36,300	36,300
Total	133,644	133,644	133,644
Variable costs			
Office help[c]	2,800	5,000	5,000
Plant labor	54,602	81,902	100,104
Electrical energy	19,867	29,800	36,423
Bagging and ties[d]	121,511	182,267	222,775
Repairs[e]	51,220	76,832	93,908
Miscellaneous[f]	59,446	89,170	108,988
Total	309,446	464,971	567,198
Total fixed and variable costs	443,090	598,615	700,842
Fixed cost per bale	3.57	2.38	1.95
Variable cost per bale	8.28	8.29	8.27
Total cost per bale	11.85	10.67	10.22
Seasonal volume (bales)	37,388	56,082	68,546

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ One employee--8 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $3.25 per bale for jute.

e/ $1.37 per bale.

f/ $1.59 per bale.

Source: Calculated.

APPENDIX TABLE 5

Estimated Annual Fixed and Variable Costs for a 30-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b] 6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	121,074	121,074	121,074
Supervision	39,000	39,000	39,000
Total	160,074	160,074	160,074
Variable costs			
Office help[c]	2,800	5,000	5,000
Plant labor	54,602	81,902	100,104
Electrical energy	29,850	44,774	54,724
Bagging and ties[d]	137,269	205,904	251,664
Repairs[e]	62,894	94,341	115,308
Miscellaneous[f]	76,871	115,306	140,932
Total	364,286	547,227	667,732
Total fixed and variable costs	524,360	707,301	827,806
Fixed cost per bale	3.21	2.14	1.75
Variable cost per bale	7.30	7.31	7.30
Total cost per bale	10.51	9.45	9.05
Seasonal volume (bales)	49,916	74,874	91,514

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ One employee--8 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.26 per bale.

f/ $1.54 per bale.

Source: Calculated.

APPENDIX TABLE 6

Estimated Annual Fixed and Variable Costs for a 37½-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	135,770	135,770	135,770
Supervision	41,500	41,500	41,500
Total	177,270	177,270	177,270
Variable costs			
Office help[c]	4,200	7,400	7,400
Plant labor	60,030	90,045	110,055
Electrical energy	34,775	52,162	63,754
Bagging and ties[d]	171,721	257,576	314,826
Repairs[e]	72,435	108,650	132,799
Miscellaneous[f]	93,042	139,559	170,578
Total	436,203	655,392	799,412
Total fixed and variable costs	613,473	832,662	976,682
Fixed cost per bale	2.84	1.89	1.55
Variable cost per bale	6.99	7.00	6.98
Total cost per bale	9.83	8.89	8.53
Seasonal volume (bales)	62,444	93,664	114,482

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Two employees--one 8 hours per day and one 4 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.16 per bale.

f/ $1.49 per bale.

Source: Calculated.

APPENDIX TABLE 7

Estimated Annual Fixed and Variable Costs for a 45-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	151,998	151,998	151,998
Supervision	44,200	44,200	44,200
Total	196,198	196,198	196,198
Variable costs			
Office help[c]	5,600	10,000	10,000
Plant labor	70,888	106,331	129,961
Electrical energy	39,621	59,432	72,640
Bagging and ties[d]	206,173	309,254	377,988
Repairs[e]	82,469	123,702	151,195
Miscellaneous[f]	108,709	163,061	199,303
Total	513,460	771,780	941,087
Total fixed and variable costs	709,658	967,978	1,137,285
Fixed cost per bale	2.62	1.74	1.43
Variable cost per bale	6.85	6.86	6.85
Total cost per bale	9.47	8.60	8.28
Seasonal volume (bales)	74,972	112,456	137,450

a/ Manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Two employees--both 8 hours per day; employed for 7, 12, and 12 months for 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.10 per bale.

f/ $1.45 per bale.

Source: Calculated.

APPENDIX TABLE 8

Estimated Annual Fixed and Variable Costs for a 60-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	223,259	223,259	223,259
Supervision	57,000	57,000	57,000
Total	280,259	289,259	280,259
Variable costs			
Office help[c]	7,000	12,400	12,400
Plant labor	103,774	155,660	190,252
Electrical energy	58,928	88,392	108,035
Bagging and ties[d]	274,538	411,802	503,327
Repairs[e]	125,788	188,680	230,615
Miscellaneous[f]	153,741	230,609	281,863
Total	723,769	1,087,543	1,326,492
Total fixed and variable costs	1,004,028	1,367,803	1,606,751
Fixed cost per bale	2.81	1.87	1.53
Variable cost per bale	7.25	7.26	7.25
Total cost per bale	10.06	9.13	8.78
Seasonal volume (bales)	99,832	149,746	183,028

a/ Two gin batteries each of 30 bales per hour, manufacturer's rating.

b/ Plants operate two 8-hour shifts each day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Three employees--two 8 hours per day and one 4 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.26 per bale.

f/ $1.54 per bale.

Source: Calculated.

APPENDIX TABLE 9

Estimated Annual Fixed and Variable Costs for a 75-Bale-Per-Hour Model Ginning Plant[a] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	257,749	257,749	257,749
Supervision	61,100	61,100	61,100
Total	318,849	318,849	318,849
Variable costs			
Office help[c]	8,400	15,000	15,000
Plant labor	114,631	171,947	210,157
Electrical energy	62,642	93,963	114,844
Bagging and ties[d]	343,442	515,158	629,657
Repairs[e]	144,870	217,303	265,601
Miscellaneous[f]	186,083	279,122	341,159
Total	860,068	1,292,493	1,576,418
Total fixed and variable costs	1,178,917	1,611,342	1,895,267
Fixed cost per bale	2.55	1.70	1.39
Variable cost per bale	6.89	6.90	6.88
Total cost per bale	9.44	8.60	8.27
Seasonal volume (bales)	124,888	187,330	228,966

a/ Two gin batteries, each of 37½ bales per hour, manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Three employees working 8 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.16 per bale.

f/ $1.49 per bale.

Source: Calculated.

APPENDIX TABLE 10

Estimated Annual Fixed and Variable Costs for a 90-Bale-Per-Hour Model Ginning Plant[a/] Equipped to Handle Machine-Picked Cotton, by Major Cost Item and Length of Season San Joaquin Valley, California, 1971

Cost item	Length of season[b/]		
	6 months	9 months	11 months
	dollars		
Fixed costs			
Investment	287,769	287,769	287,769
Supervision	66,400	66,400	66,400
Total	354,169	354,169	354,169
Variable costs			
Office help[c/]	8,400	15,000	15,000
Plant labor	130,918	196,376	240,016
Electrical energy	71,143	106,714	130,428
Bagging and ties[d/]	411,807	617,705	754,996
Repairs[e/]	164,723	247,082	301,998
Miscellaneous[f/]	217,135	325,699	398,089
Total	1,004,026	1,508,576	1,840,527
Total fixed and variable costs	1,358,295	1,862,745	2,194,696
Fixed cost per bale	2.37	1.58	1.29
Variable cost per bale	6.70	6.72	6.70
Total cost per bale	9.07	8.30	7.99
Seasonal volume (bales)	149,748	224,620	274,544

a/ Two gin batteries each of 45 bales per hour, manufacturer's rating.

b/ Plants operate two 8-hour shifts per day, 5 days per week. Actual processing time is 7½ hours per shift.

c/ Three employees working 8 hours per day; employed for 7, 12, and 12 months for the 6-, 9-, and 11-month seasons, respectively.

d/ $2.75 per bale for automatic straps and preformed fiber or cardboard bale cover.

e/ $1.10 per bale.

f/ $1.45 per bale.

Source: Calculated.

APPENDIX TABLE 11

Estimated Annual Energy Inputs and Costs for Model Ginning Plants, by Manufacturer's Rating[a/]
San Joaquin Valley, California, 1971

Bales per hour	Energy input: Hours operated per month	Energy input: Kilowatt of billing demand	Energy input: Kilowatt hours used per month	Energy input: Kilowatt hours used per bale	Cost: Energy cost per bale	Cost: Total energy cost per month	Output per month
					dollars		bales
7½	326.25	312	101,790	48.75	.72	1,498.14	2,088
15	326.25	608	198,360	47.50	.67	2,797.54	4,176
22½	326.25	725	236,532	37.95	.53	3,311.16	6,232
30	326.25	1,104	360,180	43.30	.60	4,974.92	8,318
37½	326.25	1,291	421,189	40.47	.56	5,795.83	10,406
45	326.25	1,475	481,218	38.51	.53	6,603.56	12,494
60[b/]	326.25	2,208	720,360	43.30	.59	9,821.34	16,638
75[b/]	326.25	2,582	842,378	40.47	.50	10,440.38	20,814
90[b/]	326.25	2,950	962,436	38.56	.48	11,857.12	24,958

a/ Plants operate two 8-hour shifts per day, 5 days per week. Plants of 75- and 90-bale-per-hour capacity use a lower rate schedule than that used for other plants.

b/ Plants with two processing lines, each of half the total hourly capacity.

Source: Calculated.